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**EFFECTS OF CONFINEMENT, SOCIAL ISOLATION AND
DIURNAL DISRUPTION ON
CREW ADJUSTMENT AND PERFORMANCE IN
LONG DURATION SPACE MISSIONS**

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TABLE OF CONTENTS

SECTION	PAGE
REPORT OVERVIEW	1
Purpose and Scope of Review	1
A Theoretical Perspective	2
Sensory Processing and Short-term Sensory Store.	4
Perception, Decision and Response Selection and Response	
Execution.	4
Memory	4
Attention.	5
A Further Note on Generalization: Boundary Variables.	6
Note for Mission Planners: Thesis and Organization	8
References.	10
VISUAL PERCEPTION IN SPACE.	11
Introduction.	11
Visual Performance In Space	12
Vigilance	14
Issues in Sensory Loading	15
Conclusions	17
Recommendations	17
Summary	18
Action Considerations	19
References.	20
RHYTHMIC DISRUPTION IN CREW ADJUSTMENT AND PERFORMANCE ON LONG	
DURATION SPACE MISSIONS	22
Terms	22
Rhythmic Influences in Human Performance.	24
Shift Work and Human Performance.	30
Conclusions	33
References.	36
CIRCADIAN VARIATIONS IN HUMAN MEMORY: IMPLICATIONS FOR CREW PERFORMANCE	
ON EXTENDED SPACE MISSIONS.	40
Memory and Information Processing	40
Circadian Disruptions in Memory	40
Implications for Extended Space Flight.	42
Possible Preventive Measures.	43
Summary and Conclusions	44
References.	45

THE INTERACTION BETWEEN PERSONALITY AND THE SPACEFLIGHT ENVIRONMENT . . 47

The Spaceflight Environment	48
Physical Dimensions	48
Tasks	49
Other Inhabitants	50
Organizational Structure and Climate.	50
Personalities in Space,	51
Person-Environment Interactions.	53
Observed Reactions.	53
Assumed Reactions	54
Predicted Reactions	55
The Soviet Space Experience.	55
Interactions in Other Isolated Environments.	57
Stress as a Process.	57
The Stages of Stress.	58
Stress Stages in Isolated Environments.	58
Stress-Resistant Personalities.	59
Coping With Stress.	61
Personality Traits	62
Locus of Control.	63
Intrinsic Motivation.	63
Extroversion-Introversion	63
Field Dependence/Independence	64
Type "A" Behavior	64
Sensation-Seeking	65
The Projected Space Environment.	65
Projected Person-Environment Interactions.	66
Personal Factors	66
Locus of Control.	66
Intrinsic Motivation.	67
Extroversion/Introversion	67
Field Dependence/Independence	70
Type "A" Behavior	70
Sensation-Seeking	72
Environmental Factors.	74
Personal Space.	74
Crowding.	74
Social Isolation.	76
Sensory Deprivation	77
Sensory Overload.	77
Physical Danger	78
Gender Differences.	78
Organizational Demands.	79
Conclusions.	79
A Critique of This Analysis.	79
Recommendations.	80
References	82

SLEEP AND PERFORMANCE 89

Introduction	89
Conclusion	93
References	96

SECTION	PAGE
STRESS INFLUENCES IN LONG-DURATION SPACE FLIGHT . . . . .	.100
Introduction . . . . .	.100
Models of Stress . . . . .	.102
Environmental Stressors. . . . .	.105
Individual Stressors . . . . .	.106
Group Stressors. . . . .	.109
Organizational Stressors . . . . .	.110
Selected Moderator Variables . . . . .	.110
Stress Management. . . . .	.112
Summary. . . . .	.114
References . . . . .	.115
ANNOTATED BIBLIOGRAPHIES. . . . .	.120
Visual Perception. . . . .	.121
Rhythmic Influences. . . . .	.125
Memory . . . . .	.136
Personality. . . . .	.139
Sleep and Performance. . . . .	.144
Stress . . . . .	.147

REPORT OVERVIEW

Major Frederick W. Gibson

Purpose and Scope of Review

In 1985, the Department of Behavioral Sciences and Leadership (DFBL) at the United States Air Force Academy completed a report on the psychological, sociological and habitability issues associated with long-duration space flight (DFBL, 1985), operating under the model of an orbiting space station (with an implicit mission duration of 60-90 days). The purpose of that project was to update and expand upon the Kanas and Feddersen (1971, as cited in Derrick, 1985) document which dealt with similar issues under the rubric of a 500-day mission to Mars. Consequently, the DFBL report focused on space station habitability, biological rhythms, and group dynamics.

One assumption of the 1985 DFBL report was that the reduction in the length of the proposed mission carried with it serious implications for the analysis of available literature and data. In this report, however, we view the situation more "optimistically", in that, apart from probable differences in the size and habitability of the spacecraft from one mission type to the other (which is itself arguable given recent budget constraints), few qualitative differences present themselves. In fact, inspection of Stuster's (1984, as cited in Derrick, 1985) 14 space station characteristics reveals only three dimensions that are likely to vary significantly between mission types: duration of tour (obviously); psychological isolation (which is partly dependent upon individual differences anyway); and physical quality of habitat. Hence, we feel that mission duration should not have been a driving force in the analyses we performed, and we conducted our investigations accordingly. The extent to which our findings are indeed generalizable to other missions and/or scenarios (the issue of generalizability) is addressed in the individual chapters which comprise this report. In addition, the issue of generalizability will be briefly reviewed later in this introduction.

Like the earlier DFBL report, however, this work also tries to answer the three questions posed by Derrick (1985), namely:

1. What are the sources for relevant data?
2. What impact do these topics have for human performance in space?
3. What are the possible consequences on mission accomplishment and crew functioning should these variables be ignored in mission planning?

In that regard, this report serves as a no-cost extension of the original contract, as agreed upon in 1985. Its purpose is to extend the scope of coverage of the original report and to update the databases where appropriate. As such, the topics in this paper include vision, memory, circadian rhythms, sleep, personality

issues, and stress. We have also tried to integrate these topics theoretically, as will be discussed momentarily. We make no claim that the list of topics included in this review is in any way exhaustive: far from it, we view this general problem as necessarily drawing on all aspects of psychology for a complete solution. Hence, we have tried to provide analyses of selected topics that were not covered in the earlier report and which should provide relatively significant "payoffs" for mission planners.

A Theoretical Perspective

The natural and defensible concern with mission planners must be the "bottom line"; i.e., successful performance of the mission. To ensure mission success, planners must account for and optimize all systems on board the spacecraft. But earlier space missions concentrated more on the technical and engineering aspects of flight, to the general exclusion of a very important consideration- the human aspect. Wood and Dunivin (1985) coined the term "human sub-system" to emphasize the fact that, in considering the human aspect of spaceflight, one must also consider the impact and optimization of "social skills, group dynamics, or interpersonal relationships in isolation over extended periods of time" (p. 46).

It is possible to refocus and extend the "human sub-system" concept in such a way that planners can organize a wide variety of considerations related to humans in the space mission environment. If we assume again that the main concern for operations personnel is the "bottom line" (performance), then a model proposed by Wickens (1984) provides a useful tool with which to examine more closely and systematically this "human sub-system". Not surprisingly, this model forms the basis for the organization of the current report.

Wickens proposed a model of information processing which asserts that performance, in the form of responses, is the end result of a series of complex mental operations performed on information (stimuli) gathered from the external environment. The model, as slightly revised for the purposes of this paper, is shown in Figure 1. Note that the model depicts these mental operations as a series of information-processing stages, which generally follow a linear, serial pattern of information flow. This flow is slightly modified by two phenomena, memory and attentional resources. The model, in its simplest form, therefore asserts that humans receive stimuli from the environment, perceive them, make decisions and response selections based on these stimuli (and the inputs from memory, moderated by the resources available), and ultimately make some sort of response. These responses and their consequences then become stimuli themselves and are fed back to the beginning of the model, where the process starts anew. It is important to emphasize, as Wickens did, that this model not be taken literally. It should be used, as it is

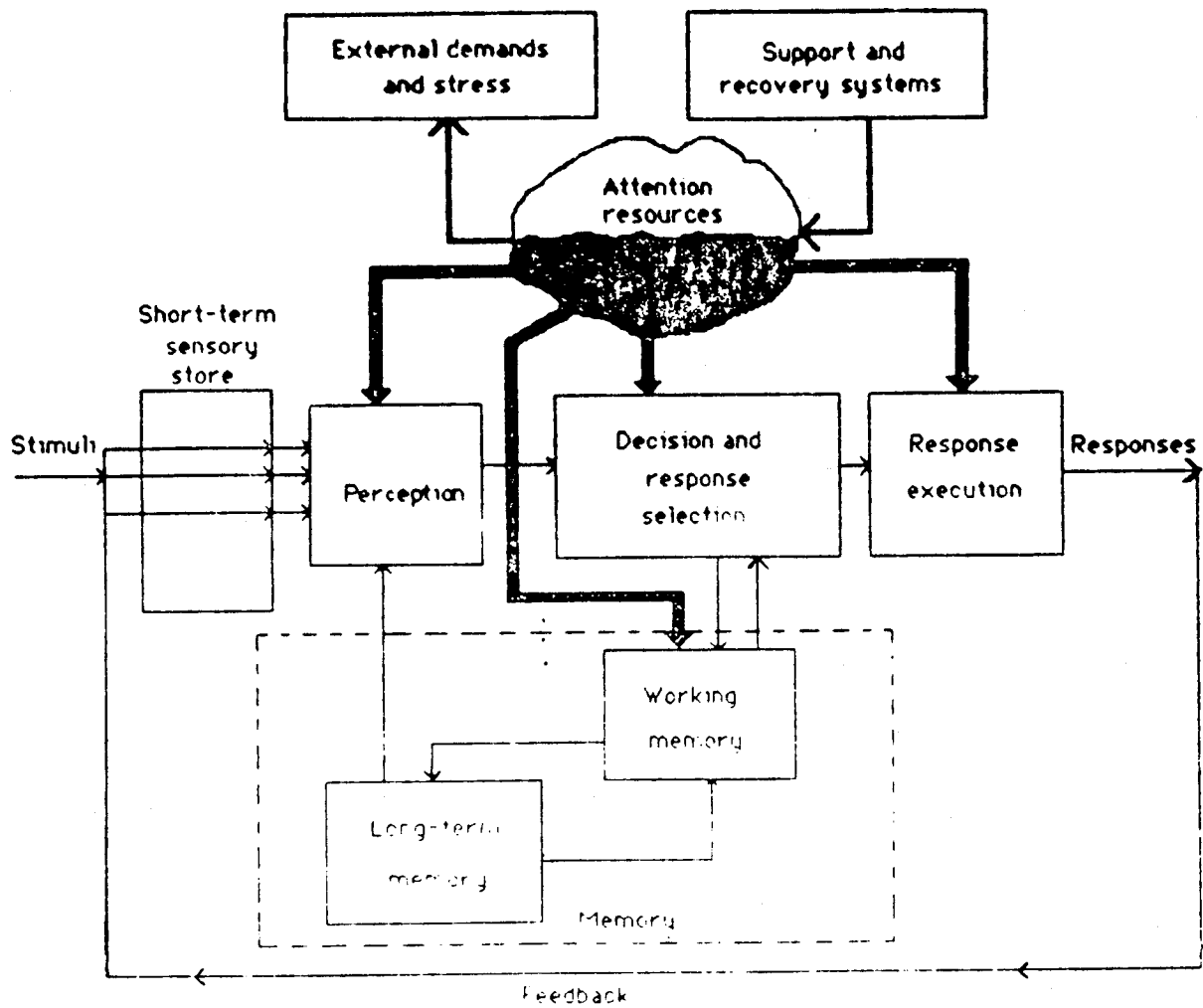


Figure 1: A Revised Information Processing Model (After Wickens, 1984).

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here, to facilitate discussion of the various components of human performance, and especially to serve as a useful tool with which to look at potential limitations in performance. It is this approach which the current investigators find most useful and which is implicit in all the chapters that follow. The following discussion briefly considers the various components of the model, along with a brief comment concerning each component's relevance to the general goal of this report.

Sensory Processing and Short-term Sensory Store (A): This portion of the model takes on particular importance because it contains the inputs from which the rest of the processes derive their function. Here, of course, we begin with the sensory systems of the human being; any limitations on these sensory systems (eyes, ears, proprioceptive, etc.) by necessity limits the quality and quantity of information that can be received by the system and therefore processed- hence the importance of this aspect of the model. This report discusses one such sensory system, the visual system, and thus the chapter by Micalizzi and Moroze will be the first chapter to follow this introduction. The short-term sensory store is a pre-processing mechanism that in effect maintains a record of physical stimuli for a very short period (ranging from less than a second to about eight seconds, depending on the stimulus modality involved) and thereby allows information to be preserved temporarily for later processing should attention be focussed elsewhere at the time of initial input. Although not a topic of discussion per se in the current report, this store is addressed in the chapter by Matthews.

Perception, Decision and Response Selection, and Response Execution (B, C, and D): This portion of the model is the main functional thrust- it is where information is first perceived (or recognized) and categorized, where decisions are made concerning what to do with or about the information, and where appropriate steps are carried out to generate the response selected. Obviously, this is a critical point in the sequence- here, "a large degree of choice is involved, and heavy potential costs and benefits depend upon the correctness of the decision" (Wickens, p. 15). One implicit influence on this functional area is the effect of the various rhythms our bodily systems are subject to, and the chapter by Winstead discusses in some detail these rhythmic influences.

Memory (E): A second moderating influence on the information processing sequence, memory works in several ways. In one sense, it serves as a relatively permanent repository of information (long term memory) which initially helps by allowing incoming information to be recognized and categorized. Later, memory interplays with the decision and response selection functions: in the output sense, it provides critical data (previously stored) that can be used to initiate and select response decisions; in the input sense, information deemed appropriate for further storage can be channeled to memory and rehearsed to maintain it in working memory or learned to upgrade it to a long term memory trace. The

influence of circadian rhythms on memory is discussed in the chapter by Matthews.

Attention (F): As the model implies, all the functions in the main processing sequence (as well as memory) rely heavily on attentional resources to function. In other words, to effectively perceive information, remember it, or to select and execute responses, individuals must to some extent allocate attention to these tasks. More importantly, attention can be viewed as a limited resource (as indicated by the shaded portion of the bubble) that can be depleted or replenished to varying degrees. It is therefore critical to understand the types of phenomena and processes that can limit the amount of attention available or add to one's ability to properly attend to the task environment at hand. These concerns are conceptualized in the model respectively as external demands and stress (G) and support and recovery systems (H). It is in these areas that this report makes the bulk of its contribution. One phenomenon that obviously influences both concerns is sleep. Very simply, lack of sleep or disturbed sleep can diminish the attention one is able to bring to bear on a task through its effect on fatigue and bodily rhythms. Conversely, proper sleep routines or recovery periods can do much to restore the "attentional pool", and hence a separate chapter, by Smith, investigates this issue in more detail.

A subsequent chapter deals with crew member personality characteristics, and how these characteristics interact with characteristics of the space mission environment. To the extent that there is a lack of fit between the two sets, the individual may experience stress and/or in some other way be unable to optimally attend to mission concerns. On the other hand, it may be that certain personality types are better suited to the space mission environment, and the person-environment fit should be encouraged and optimized wherever possible. Miner's chapter treats this topic in significant detail.

Finally, stress strongly influences, we believe, the chances for mission success through its unique effect upon the attentional pool. It is common knowledge, and has been discussed in the public media, that crew member stress is an ever-present danger and has effected the operation of at least one American space mission already (Smith, 1986). As with the other influences, crew members are not likely to be effective if they are spending inordinate amounts of time and energy dealing with experienced stress in lieu of attending to task accomplishment, so this topic is also considered in a separate chapter, written by Austin.

The final component of the model is feedback. What this implies is that individuals continually monitor the consequences of their actions. These perceived results, however they are represented, are fed back to the system's start point and serve as one set of sensory inputs that begin the processing sequence.

A Further Note on Generalization: Boundary Variables

Psychology is a particularly young science, being only about 100 years old, and space science and the American Space Program especially are still in the infant stage of development. As a result, many of the conclusions and relationships thus far determined are somewhat tentative, as is the "robustness" of these relationships. In other words, how confident can we be in the relationships between variables that have been identified in laboratories or analogue environments here on Earth, or as a result of study in actual space mission environments? This is the question of generalizability, the extent to which research findings (especially laboratory studies) can be applicable to other settings, populations, treatment conditions, or measurement systems (Fromkin and Streufert, 1976).

Derrick (1985) provided an excellent overview of this issue in his introduction to the previous report, espousing the view that, although direct generalizations were not possible in many cases, "certain patterns of behavior have been documented in so many situations that a real non-zero probability exists that they will occur in space as well" (p. 5). This issue needs some clarification. Yes, generalizability (external validity) is the degree to which experimental effects can be applied to other "populations", and it is a function of judgement on the part of scientists and practitioners; however, such judgements need not be made blindly or haphazardly. In fact, the basis for generalizability decisions "resides in the identification of critical differences between a specific research setting and a specific organizational setting" (Fromkin and Streufert, p. 431; *italics added*). In other words, the question is not whether the research setting (or analogue environment) is different than the target environment (space mission), but whether or not these environments are different in relevant ways. Too often, researchers or reviewers apologize for lack of generalizability of noted results, when in fact the studies at hand may be quite relevant. In these cases, more time could be spent making a systematic determination of critical differences and less time apologizing.

These critical differences, which may be the presence or absence of a factor that is essential to the unaltered occurrence of a stimulus-response relationship (Fromkin and Streufert), are called "boundary variables". As before, generalizability decisions should be based not on the "similarity" of two environments, but on the role played by boundary variables. How is this done? Fromkin and Streufert suggest that judgements be made on the basis of the results of other relevant research or on the experience and insight of the individual involved. Of course, trivial differences are not included in the analysis. Research settings, then, whether they be experimental studies or reports from analogue environments, are not necessarily artificial or unreal. Instead, we look at the differences between the research and target settings as potential boundary variables. The actual procedure, as

detailed by Fromkin and Streufert, proceeds like this; first, identify all the potential boundary variables between the research and target settings (if there are any); second, judge or predict the potency and/or direction of the effects of these boundary variables. Sometimes this latter step does include guesses about general laws of behavior; however, as literature bases increase, fewer and fewer guesses will be involved. Even so, the technique is a more systematic and reasoned approach despite accounting for a scanty database in any particular area.

Perhaps some examples will be instructive. In the first example, let's assume we are doing some research in the laboratory concerning reaction time and the type of stimulus used to generate the reaction. We want to generalize the results to older people, because we want to design alarm systems for nursing homes. Now, most psychological research, as we know, is conducted in universities using 18- to 22-year-old students. If we determine in our study that auditory signals are responded to more quickly than are visual signals, our question becomes whether this finding is generalizable. One obvious difference between the two settings is the age of the populations, but is age a boundary variable? We think not; based on our experience and the weight of many psychological reports, we have no reason to believe that the relationship between stimulus modality and response time is effected by age of the subject. Hence age, although different in the two settings, is not a critical difference (i.e., it is not a boundary variable). On the other hand, let's say we're investigating the efficacy of teaching methods, using the same two settings. At the university, we discovered that the best way to teach our college students was to use lots of visual aids, because it helped the students organize more quickly and recall better. Is this a generalizable result? Probably not- elderly people's short-term memory is better for things they hear than it is for things they see (Arenberg, 1967, as cited in Worchel and Shebilske, 1983). In this situation, then, age is not only a difference between the two settings, it is also a boundary variable.

All the chapters in this report to some extent (although in most cases implicitly) deal with the issue of generalizability and boundary variables. However, because of the youthful nature of the discipline of space science, we are, as mentioned earlier, quite limited in the conclusions we can draw at this point. The challenge we pose for researchers in this area is to develop a taxonomy of key relationships and their boundary variables, much like the taxonomy of analogue-space station relatedness suggested by Derrick. Such a taxonomy would, for each general discipline (like vision, memory, group dynamics, and the like), list each major relationship (whether it be bivariate or more complicated), the most important boundary variable(s) effecting this relationship, the nature of the effect (direction and magnitude), and possible solutions. In this way, mission planning might take on a much more research-based and systematic foundation. Reviews like this are the first step in constructing such taxonomies, but relevant space studies must be conducted to confirm some of the

earth-based findings before we can proceed with some confidence.

One very general and somewhat intriguing hypothesis might be offered here. It seems rather ironic (or at least counterintuitive) that the types of studies which are most generalizable here on earth may in fact be the least so in the space mission environment. For example, psychophysical studies rarely are challenged on their applicability, yet we may find that many visual relationships are altered in space because of gravitational changes, cosmic radiation, lack of perspective cues, and the like. On the other hand, relationships discovered in the social psychological arena may remain quite unaffected by changes in setting (territoriality and leadership issues might not be changed at all, for example). Nevertheless, this report, like the earlier version, can do no more than sensitize mission planners to observed relationships among variables that seem to be rather consistently documented, and suggest that these relationships are at least possible in space.

Note for Mission Planners: Thesis and Organization

The thesis of this report remains the same as that of the earlier version; the organization, though, has changed somewhat. We still believe, as Derrick pointed out, that people in space missions will behave as people regardless of the amount of training and motivation involved. This is especially true as the length of space missions increases.

The organization of the report, however, follows the general scheme of the information processing model of Wickens discussed earlier in this chapter. As before, the focus of this work is not the generation of theory, nor is it to provide an exhaustive review in each of the topic areas; rather, the following chapters glean from their respective databases those studies and conclusions which are relevant and meaningful in the current context; namely, planning an operational space mission of relatively long duration. This charter necessarily drives the content and structure of the report. We have tried to make the report more accessible and useful through the inclusion of several new items. The revised order, driven by a theoretical model, should help in integrating the information. In addition, each chapter is a relatively short work, written in non-technical language wherever possible, so that individuals in the planning process can understand the information without resorting to a dictionary or reference book. Further, each chapter is followed by a summary or list of implications/conclusions which may be used as a quick reference or review of the material contained therein. Finally, appendices at the end of the report contain separate annotated bibliographies for each of the topic areas. These bibliographies are short summaries of the major works reviewed in area, and should serve both as further references for people wishing to pursue a particular topic as well as a point of departure for further work. We hope the reader finds these new

inclusions useful.

One final note: the space mission depends on a proper person-job match for optimal functioning. That is to say, there are two "degrees of freedom" associated with space missions, one for the individual crew member or crew as a unit and one for the environment. As a result, the chapters presented here provide information which may be used in more than one way: planners can on the one hand focus on selection, training, motivation, or other techniques to "engineer" the type of person or crew involved in space missions; or planners can focus on the environment, and engineer the tasks, schedules, and vehicle(s) to more properly accommodate the characteristics of its occupants. We believe the answer lies in a synthesis of these two approaches, with the particular approach selected at any particular time being a function of the efficiency, availability, and costs associated with each approach. Therefore, the informed judgement and experience of mission planners remains the ultimate criterion for the success of each endeavor; our goal has been to provide some information and experience so that these mission planners might swing the odds a bit more in their favor.

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Introduction

The human visual channel is inarguably the richest and most important source of information about our environment. The complex interaction among the physiological, psychological, and environmental variables of human visual performance on earth has been well documented in the research literature (Carterette and Friedman, 1975). However, relatively scant attention has been paid to possible visual decrements which may occur when we place the human being in space. In addition, as the duration of these manned space missions continues to increase, previously unreported visual problems may emerge, and presently manageable decrements may become unmanageable. As a result, the absence of data on visual performance may unnecessarily jeopardize the success of future manned space flights.

The problem with this lack of data on visual performance stems, in part, from two sources: the lack of analogous "space" environments here on earth; and the belief that our carefully selected and well-trained astronaut corps will be able to adapt sufficiently to any changing environmental demands of space and accomplish the mission. The first problem, that of generalizability of results from our earthbound laboratory experiments to the operational space environment, is generally recognized and approached in the research in a similar way. The approach of this paper will be similar to other reports (e.g., Department of Behavioral Sciences and Leadership (DFBL), 1984), which is to examine plausible relationships among relevant variables in a variety of research settings and then suggest these relationships as also possibly occurring in the space environment. It seems reasonable to assume that, in the absence of evidence to the contrary, many of these relationships operate under the same basic rules of human behavior and, therefore, are relatively stable phenomena of both earth and space environments.

The second problem may be more difficult to deal with since it involves subjective perceptions of an individual's ability. It is a basic premise of many papers written in this area that human space travelers will behave as humans first (DFBL, 1984). Although this seems obvious, it is important to bear in mind that all the technical and professional training in the world cannot completely compensate for certain inherent limitations of our visual processing system. In addition, as crew composition changes to a more heterogeneous mix of astronaut and mission specialist/scientist, we can expect less benefit to be derived from the selection and training programs (See Miner, 1987). Whereas many issues may not play a major role in short duration missions, they will play an increasingly important role as mission durations lengthen. Therefore it is important to be sensitive to these issues as we plan for and design manned space systems for longer duration missions.

This paper will briefly describe how overall human visual performance operates within the space environment. The subsequent sections deal with some more specific issues of visual performance -- vigilance and sensory loading. Finally, a summary and list of recommendations will follow.

Visual Performance In Space

The role of the astronaut in space has gradually evolved from that of a passive observer of space operations to an active operator who is not only capable of providing a backup capability to the automatic spacecraft systems, but who can also assume a number of other functions at his/her discretion, such as piloting, conducting experiments, performing maintenance, etc. (Jones and Grober, 1961). The projected space station environment significantly enlarges the scope of human participation in the overall tasks and activities of a mission. As human participation continues to increase (and since humans are primarily visual information processors), the visual capabilities of the astronaut will become one of the more dominant forces in gaining and processing information from the space environment. It follows that the need to effectively integrate the astronaut into the overall space vehicle system as more than a redundant component to spacecraft systems is well understood, and was known as far back as the Mercury program, where not only increased reliability but flexibility were the stated goals (Zink, 1965; Brown, 1964). As we become more dependent on the human component of the system, we must consider both the human's capabilities and limitations especially as they apply to the visual channel and the sources, types, and rates of information we expect the human to effectively process through this channel.

The visual environment in space is, and will continue to be, complex and demanding from a human information processing viewpoint. In contrast to the notion of reduced sensory input implied in the sensory deprivation studies of the 1950's, future space travelers may, at times, be bombarded with perceptual and sensory information from both inside and outside the spacecraft (Miller, 1961); however, the quality and meaningfulness of that stimulation will continue to be areas of concern for mission planners (Cameron et al., 1961). The issue of meaningfulness will be discussed under the area of sensory loading. In addition to the information the astronaut must deal with, there are certain considerations concerning the physiological aspects of vision that must also be addressed.

It is not quite understood what enduring visual problems will be brought on by long duration space flight. Reports of light flashes aboard spacecraft during Appollo missions (Johnston and Dietlein, 1977) may have significance for long-duration spaceflight. Whether these light flashes, which are thought to occur as a result of heavy atomic particles striking the retina, cause damage to eye or brain tissues is not fully understood (Johnston and Dietlein, 1977). Additionally, it is not fully understood whether increased intraocular pressure results from the edema experienced during early stages of spaceflight and whether semi-permanent or permanent damage results. Nevertheless, these phenomena do signal the possibility that visual impairment, at least to a minor degree, is possible in the space environment. Whether or not it portends a significant or cumulative decrease in visual performance or reliability cannot, however, be ascertained given the nature of the literature thus far. It is still arguable, though, whether any consistent or persistent perceptual changes occur as a result of extended exposure to the space environment (Connors et al., 1985). However, in order to assess any possible visual problems found due

to the space environment, we need to understand the differences between the visual environments on earth and in space. Brown (1964) lists and discusses several hazards to vision in space, including: high illumination levels; ionizing radiation; exotic fuels; and acceleration. In addition, more specific visual capabilities can be affected by the unique conditions found in space environment. Grether (1965), for example, examined several conditions that may affect target visibility, including background illuminance, target luminance, target contrast, target area, and transparent areas. For instance, target contrast (defined by the ratio of luminance difference over the luminance of background) could range in space from "very nearly minus one, through zero, to positive values approaching infinity" (p 32). This enormous range of contrasts, which depends on the orientation of the observer and target (e.g., looking toward the sun, toward the earth, etc), can have a dramatic effect on acquiring the target. However, the general lack of research in these areas to date prevents us from drawing firm conclusions at this point.

Normal vision cues used to estimate object distance will also be absent in space. Increased contrast between objects in the sun and their respective shadows, lack of light dispersion commonly found on earth due to earth's atmosphere, and inexperience with object size and their position relative to each other can decrease an operator's ability to estimate object distance as well as object size. For example, let's look at a particular tree in front of your home. If we eliminate the familiar objects (house, other trees, etc.) and "place" the tree in space, without your prior experiences and relationships to other familiar objects, absolute judgement of tree size is more difficult. Hyman (1965) looked at various ways to estimate distances using angles of objects subtended at the eye and luminance and illuminance aspects and found that relatively good predictions of object size and distance can be obtained with these methods. In addition, Pigg and Kama (1961) reported a decrease in visual acuity during brief periods of transient weightlessness. This decrease, however, was concluded to be insignificant (6-10%). Nevertheless, while brief exposures to weightlessness may not cause a significant vision decrement, long duration exposures may. Therefore, the space environment does include specific challenges to the human's perception of the environment and may result in significant performance effects for such activities as target search and acquisition, distance estimation, and spacecraft maneuvering. These issues are especially important when automatic/computer systems are inoperable and the human operator must function independently of them.

One of the most important issues dealing with visual performance inside the space vehicle is visual disorientation caused by information received through the spacecraft visual apparatus being in conflict with a person's perceived frame of reference (Chambers, 1964) and other sensory inputs (e.g., from the vestibular apparatus). In a weightless environment we can locate controls and displays anywhere in the environment where space permits, since the human could theoretically "float" to a location. However, this is not preferred due to sensory conflict. In addition, our experience with the Skylab missions suggests that the interior arrangements of the crew compartment should be based on a consistent gravity orientation where possible, although slight deviations from this ideal should not seriously degrade performance (NASA, 1974).

The data on overall visual performance to date in space are encouraging, although the lack of reported problems in the literature may be a function of our current inability to identify and isolate those conditions under which visual performance deficits will be observed. Be aware, however, that as crew numbers and composition changes and space missions become longer, other as yet unanticipated problems may develop. Perhaps the most needed element of space research is a coordinated and comprehensive research program aimed at evaluating human visual performance during an actual space mission.

Vigilance

Human vigilance performance is one of the most widely studied areas in all of the behavioral sciences. The typical vigilance scenario involves a human subject who must attend to an environment that provides rare, oftentimes weak signals, for an extended period of time. In general, the literature has shown that, for most types of tasks, vigilance performance decreases over time with the major drop in proficiency occurring within the first thirty minutes and then stabilizing somewhat after an hour. The problem is that very few studies have gone beyond four hours' duration, so that we know very little about what happens to a truly vigilant operator's performance over long periods of time. The overwhelming weight of the experimental data, however, strongly supports the idea of avoiding human vigilance tasks unless one is willing to accept some decrease in performance (Jerison & Pickett, 1965; Parasuraman, 1986).

We can envision, however, several scenarios in the space environment where it may become unavoidable to use the human being as a systems monitor and where, therefore, vigilance considerations will become important. This might happen, for example, if automatic systems fail, or if costs or weight penalties intentionally force the monitoring function on the astronaut. The vigilance problem may become more serious in space missions of long durations where the day-to-day operations are relatively routine and uneventful and the excitement of spaceflight gives way to the apathy and boredom of "just another job". A similar result was reported in some of the early chamber flights where subjects described decreased vigilance and feelings of annoyance and restlessness which persisted for several days afterward (Simon et al., 1961). We can also predict that vigilance performance will interact with fatigue and environmental factors, so that a comprehensive theory of vigilance is needed before useful applications can be made.

One can consider the vigilance problem within the context of signal detection theory (Egan, Greenberg and Schulman, 1961). Signal detection theory (SDT) assumes that in any environment where a signal is present there will also be noise. This noise can be due to environmental sources, such as white noise, or other signals that are not important to the task. The probability that both noise and signal will be present at any given time is a function of each event's probability of occurrence. SDT states that an individual will identify an event as a signal if its strength is above some criterion level; if the event's strength is below that criterion, the individual will identify the event as noise (or not identify the event at all). This criterion level is based on the penalties associated with correctly identifying, incorrectly identifying, or failing to identify the event appropriately. Within this context, then, we may be able to consider vigilance effects as being due primarily to changes in observer criterion. The particular decision made depends upon whether or not the observation exceeds the criterion value; the criterion level, in turn, depends on the observer's detection situation (Swets, Tanner and Birdsall, 1961).

Jerison and Pickett's (1965) recommendation for manned space systems based on this approach would be to increase the a priori signal probability by increasing sensitivity of the system (detecting more targets) or by using longer units of time intervals. In addition, it is suggested that monitoring jobs be made analogous to the job of quality control specialists who check the adequacy of system performance rather than just detecting the rare failure.

Issues in Sensory Loading

Prior to the 1960's, it was commonly thought that one of the biggest challenges facing man in space was dealing with reduced sensory information. Numerous studies were conducted which sought to identify consistent patterns of human behavior in response to reducing the amount of energy coming through the sense organs (Zubek, 1969). Although there is considerable evidence that a certain minimal rate of information input is required for an organism to function normally, it is generally thought to be the amount of patterning, not energy, in the information input which is significant (Miller, 1961). Miller (1961) relates a good example to illustrate this point: "So you may put white noise into the ear at a loud intensity, and the subject can still suffer from sensory deprivation, because he hears noise only, without any informational patterning of sound." (p 218) The requirement for meaningful stimulation is the same for vision. From our previous discussion of the vigilance decrement, we can now see how decreased monitoring performance over time may be explained by lack of meaningful sensory stimulation. In terms of sensory deprivation in long duration space missions, we see that where the emphasis should be is on the quality of the sensory input and the meaningfulness of this information to the human rather than the quantity of stimulation. Therefore, it would not be appropriate for the human to just attend to signals, but to attend to important, relevant signals. In addition, the signals should have qualitative meaning - instruct operator to perform a task, for example.

The other side of the sensory loading coin is the phenomenon known as "overload". Just as human factors engineers are concerned with high mental workload levels in aircraft, air traffic control systems, and nuclear power plants, sensory overload in the space environment holds a similarly significant position in the design and development of manned space systems. In general, the typical overload scenario begins with increase in the rate of information input being matched by a corresponding increase in the rate of information output of the human until the channel capacity is reached. At this point, the rate of information output will be maintained at channel capacity even though the information rate at the input is still increasing. Beyond this saturation point, increasing the rate of information input further will cause a dramatic drop in output, sometimes all the way to zero (Miller, 1961). And with the multitude of tasks an astronaut may be performing at a given moment in time, the chances for sensory overload, and therefore performance decrements, increase dramatically. Obviously, there will be critical tasks that astronauts will be required to perform during which sensory overload could be catastrophic. In addition, there may be an interaction between sensory load and time where sensory loading takes on a different perspective (when introduced in longer space missions). A task performance requirement by itself may not induce an overload situation. However, if viewed with all tasks done that day (week, month, etc.) it may indeed cause an overload. Therefore, pacing of sensory stimulation and astronaut workload should take on increased importance.

Miller (1961) also looks at information loading from a systems perspective. Certain simple systems (neurons, single cells) have a much greater channel capacity than complex systems (humans, small groups). For example, he found that a single neural fiber of the sciatic nerve of a frog, when stimulated electrically, has a channel capacity of 4,000 bits a second. In contrast, a four-man group (using Miller's apparatus) has a maximum channel capacity of 3 bits a second. It appears that the more components in an information processing system, the lower the channel capacity. Using this systems framework, the number of components within a system takes on greater emphasis. Since long duration space missions will most likely include some number of operators and operator-machine interactions (greater than one) we must consider this "group effect" on system performance. Miller believes that the reason for this decrease in performance is due to the lowest-capacity member of the system (analogous to the weakest link in the chain). Since the breakdown occurs at the boundaries between two components of the system, attention must be focused on this interface (whether human-machine or human-human). This is a classic design problem. If information is lost at this juncture, then to optimize overall system information processing performance we need to ensure maximum transmission between members of the system. Display design, control interfaces and environmental factors such as noise, thermal stresses, etc. need to be addressed in this context. In addition, more crewmembers and crew mixtures (pilot, scientist-specialist) with their differences in training and experience, should be addressed in a systems context to optimize system (rather than individual) performance. In fact, a great deal of research exists for group interactions in a "social" or psychological context, but performance due to information processing changes within a system requires additional study. As a fictitious example, optimizing the pilot's position by incorporating what Wolfe would say as a pilot with the "right stuff" may actually decrease overall crew performance. An independent pilot may not work effectively within a crew environment.

Chambers (1961) discussed several ways in which sensory overload may be expressed by astronauts, including omission, filtering, approximation, queuing and escape. These strategies for dealing with sensory overload are adaptive in that the degree to which they are used depends on the astronaut's subjective assessment of the workload demands he is being tasked to satisfy. The problem, of course, is that the astronaut may not be optimizing his performance; however, a very "smart" computer system utilizing artificial intelligence applications could dynamically reallocate task demands much more quickly and with much greater efficiency than the human decision maker. Also, tasks which are taken away from the astronaut are not ignored, but rather automated by being transferred to the control of the computer for processing, and the results fed back to the astronauts at the proper time.

CONCLUSIONS

There is relatively little information on human visual performance in the space environment. Reasons for this include a lack of analogous space environments on earth in which to conduct research and the reliance on selection, training, and human capabilities to overcome any visual decrement that may be experienced in space. The successes of our space program to date may, in fact, lull us into complacency as we extrapolate our findings from short duration missions to longer duration missions. Short duration missions may not permit deficits in human visual performance to be observed. The result is a potentially dangerous underestimation of the effects of space on visual processing and performance.

As we look at human visual performance, we find some data that suggest the space environment is more challenging than earth's for target search and acquisition, object size and distance estimation, and spacecraft maneuvering. In addition, data support some physiological changes to the visual system that may have a greater impact on long rather than short space missions.

The interaction of visual performance with vigilance tasks and varying amounts of workload causes some concern because of the lack of research looking at visual performance under these concepts. In addition, there appears to be a lack of a coherent systems approach in studying visual performance. The tendency has been to optimize individual (human or machine) performance; this does not necessarily ensure optimal system performance which, however, is the true object of concern for longer duration missions.

RECOMMENDATIONS

Initiate research programs to evaluate human visual performance integrating vigilance tasks and varying workloads within a systems context. From a human information processing perspective, these areas must be addressed within a cohesive program. Again, optimizing individual performance does not ensure optimal system performance.

As in any work environment, we must design the tasks to take advantage of the human operator's capabilities while minimizing the human's limitations. Therefore, we should avoid assigning monitoring tasks to the operator. Human task performance, even with the limited methodologies of current studies, decreases when it is required within a vigilant environment. Redesign of task structures to eliminate human vigilance tasks should always be considered. Current technologies (artificial intelligence, expert systems, etc.) allow for an increased amount of automation to be designed into these tasks. However, if we rely on the human as a backup to these systems, we must consider the probable decrease in performance when the human takes over the task at hand.

The type of sensory information is also an important consideration. Rather than concentrating on the amount of information presented to the operator, we must concentrate on the quality of the information presented. Therefore, we should not automate every task in the environment only because the technology can support it. We need to ensure that we look at the task environment from a systems perspective. Ensuring meaningful tasks remain for the operator will increase operator performance and counteract any possible vigilance effects.

SUMMARY

1. There is relatively little information on human visual performance in the space environment.
2. Our manned space experience so far has revealed few problems in the visual perception and processing area.
3. As mission durations become longer and crew composition changes, visual performance issues may become more important, due to the proposed increased role of the human's visual processing system.
4. Data support that the visual environment of space may be more challenging than the visual environment on earth. This may become increasingly more apparent on missions of longer duration.
5. Visual disorientation can result from a conflict in sensory information between the visual system, vestibular system, and the controls and displays in the work environment.
6. Human vigilance performance and sensory loading are two of the more important areas of visual performance in the space environment.
7. Human monitoring performance consistently deteriorates over time. This is known as the vigilance decrement.
8. Increasing the a priori signal probability and changing the nature of the monitoring task to be more analogous to a quality control task are two ways of dealing with the vigilance decrement.
9. The quality of sensory input is more important than the quantity in explaining performance decrement during sensory deprivation studies.
10. Sensory overload is, and will continue to be, an important issue in long duration manned space missions.
11. New technologies (artificial intelligence, expert systems, etc.) will become an important tool for aiding the astronaut during critical phases of the mission when information rates are high.
12. Current research methods focusing on visual performance in a reduced sensory environment are inadequate. In fact, viewing the space environment from a sensory deprivation perspective may be misleading. The sensory environment is certainly different, but not necessarily reduced from an information processing perspective.
13. Physiological changes to the visual system may impact longer duration mission success.

ACTION CONSIDERATIONS

1. Initiate an integrated research program to evaluate human visual performance (especially visual information processing) in the space environment. Consider not only the interaction of vigilance tasks and operator workload, but the overall systems context as well.
2. Avoid assigning monitoring tasks to the astronaut. If monitoring tasks are present, consider changing task structure to improve performance.
3. Emphasize quality of sensory information, not quantity, as part of those studies which are investigating the effects of sensory load.
4. Investigate new technologies such as artificial intelligence applications to deal with sensory overload and underload conditions.

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Rhythmic Disruption in Crew Adjustment and Performance on
Long Duration Space Missions
Charles L. Winstead

How well man performs in the long term space environment will certainly depend on many variables, as indicated in the model which opens this report. One variable which will directly impact man's performance in space concerns the adjustment of his or her biological rhythms. It is well known and has been well documented that performance, both cognitive and psychomotor, not only varies measurably during the day but over longer periods of time as well (Colquhoun, 1981). Chronobiology is the study of rhythmic cycles and refers to the cyclical fluctuation in hormonal release, sleep/wake cycles, arousal patterns, and a host of other physiological and psychological functions in both humans and infrahumans (Carlson, 1985).

The manner in which these cyclical rhythms affect human performance has been a major topic of research and review, especially in the last decade, and understandably so. Not only are the cyclical effects of human performance a primary concern in long term space missions, but private industries are also concerned with determining how and when their workers are at their peaks as well as at their low points. Indeed, recent surveys indicate that over 27% of male workers and 16% of female workers have jobs that require them to work on differing shifts, including days, evenings, and nights (Danchick, Schoenborn, & Elinson, 1979; Ward & Stobbe, 1984). How human performance can be altered by these changes in work times is, therefore, of great theoretical as well as practical consideration.

In the past five years there have been numerous articles published which review the research of cyclical fluctuations in human performance (Alluisi & Morgan, 1982; Colquhoun, 1985; Conners, Harrison, & Akins, 1985; Folkard & Monk, 1983; Matthews, 1985; and Winget, DeRoshia, Markley, & Holley, 1984). The purpose of this paper is not to reiterate what these authors and others like them have already stated, but rather to collate from their efforts those conclusions and findings relevant to long term space travel and to provide an operational framework within which these findings may fit. In short, this paper will extract from known findings within the past five years pertinent information and offer some operational considerations which may be used in the immediate future.

Terms

There are numerous rhythmic cycles which affect human performance. Diurnal rhythms or infradian rhythms as they are sometimes called, are those cycles that occur during the waking

day (e.g., attention span, short term memory, etc.). Circadian rhythms are 24-hour periodicities in physiological and psychological functions (e.g., sleep/wake cycle, body temperature, etc.), while infradian rhythms are those periodicities of longer than 24 hours (e.g., menstrual cycles) (Halbery, Cornelissen, Carandente, & Katinas, 1977). Biorhythms supposedly are composed of three cycles; a 23-day physical rhythm, a 28-day emotional rhythm, and a 33-day intellectual rhythm. These rhythms each follow a sine wave pattern and are subdivided into a minus or recuperative period and a positive or ascendent period with the latter being a favorable time and the former being a period of declining performance. Biorhythmic critical days are defined as those which occur at the midpoints of each of these sine waves and are believed to be dangerous because the individual may be caught between ascending and descending periods. Supposedly, it is during this critical period when one is most susceptible to the affects of environmental influences and external stresses. Unlike the other three rhythms mentioned already, biorhythms have largely been discredited as having any reliable or conclusive affect on human performance (Latman & Garriott, 1980; Winget et al., 1984; and Winstead, Schwartz, Mallott, & Bertrand, 1984).

Here on earth these various diurnal, circadian, and infradian cycles are regulated by what are assumed to be two primary oscillators. These oscillators function to keep the cycles synchronized with the environment and with each other. One type of oscillator is termed "endogenous," as it is, hypothetically, located somewhere within the organism, usually assumed to be deep within the brain. These primary oscillators are very strong and are, therefore, relatively immune to the external environment or to other exogenous (external) factors. The temperature rhythm in humans, for instance, is said to be under the control of an oscillator which is relatively independent of exogenous fluctuations (Folkard, Wever, & Wildgruber, 1983).

The other oscillator is not as strong or dominant and is therefore more sensitive to influences by exogenous factors or environmental cues. These external or environmental cues are termed "zeitgebers," ("time-givers") and include such "clocks" as sunrise and sunset, meal times, social hours, working hours, radios, T.V.s, mechanical clocks, etc. (Wever, 1980). The sleep/wake cycle is said to be under the control of zeitgebers such as those mentioned above. These two oscillators interact and keep each other synchronized. However, in the absence of zeitgebers or when zeitgebers are somehow altered (e.g., during transmeridian flight or long term space missions) these two oscillators may become desynchronized, and this desynchronization or dysrhythmia may adversely affect human performance in a variety of ways. (Colquhoun, 1984).

Human performance cycles and the possibility of their desynchronization have the potential to make the difference between an otherwise successful mission and a very successful long duration space mission, especially when mission duration exceeds several of the longer cycles. Indeed, as Conners, Harrison, and Akins (1986) state, "We are seeing a transition from an era of visiting and experimenting in space to an era of living in space and of routine commercial production" (p. 906). For this reason, the specific effects of rhythmic influences on human performance need to be considered. Two areas in which disruptions may manifest themselves are in effects over the day and the effects of working differing shifts.

Rhythmic Influences in Human Performance

The body temperature of humans rises and falls in a very reliable and rhythmic manner over the period of a day. This cyclical fluctuation usually reaches a peak of 98.35 F between 1600 and 2000 hours and then drops to a low of 97.16 F between 0300 and 0500 before beginning to rise again and repeat itself (Colquhoun, 1971). Figure 1 graphically represents this very predictable circadian rhythm for an individual subject.

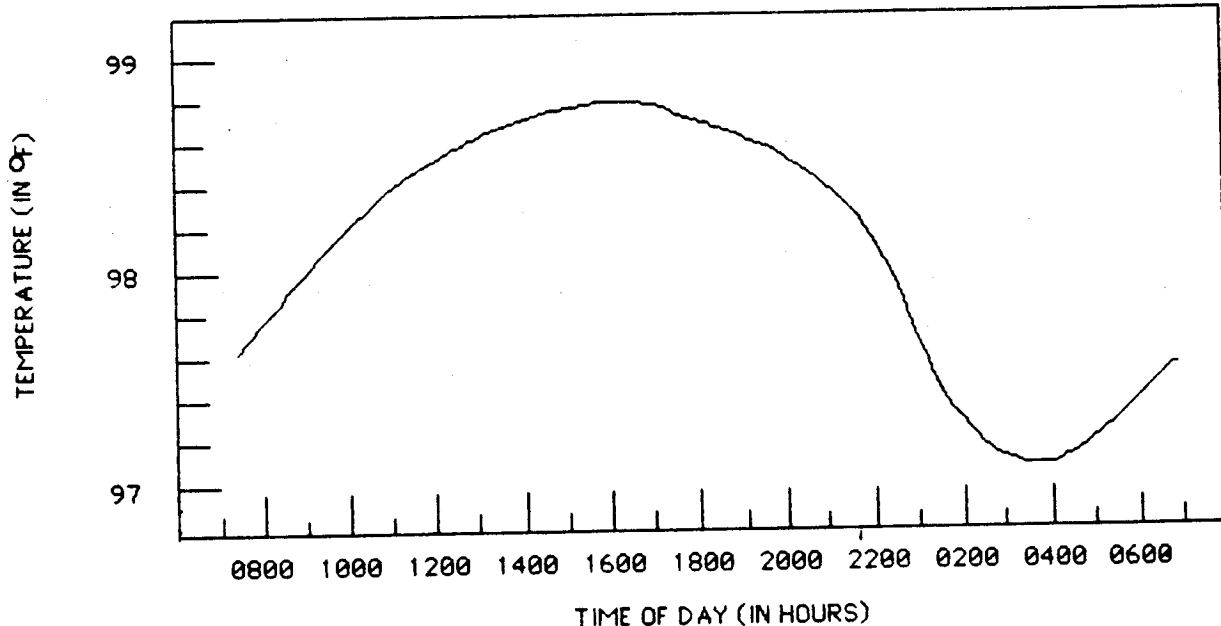


Figure 1. A typical circadian rhythm of human oral temperature. After Alluisi and Morgan (1982).

Hockey and Colquhoun (1972) found that both performance speed and body temperature are low early in the waking day and steadily increase over most of the day, finally reaching a maximum at about 2000. Again, there would seem to be a predictive relationship between temperature and performance on at least some identifiable tasks. Short-term and intermediate memory scores, on the other hand, usually steadily decline over the day, while long-term retention increases over the day. (Human memory has its own circadian rhythm and will be considered here only tangentially as it relates to performance. For a more complete discussion of memory and possible implications for extended spaceflight, see Matthews (1987)).

Folkard, Knauth, Monk, & Rutenfranz (1976) also investigated the correlation between temperature and performance on various memory tasks. Their approach was novel in that they used a serial visual search task in which the working memory load requirements could be systematically varied. That is, they could have their subjects search for either a two-letter target (low working memory load), a four-letter target (intermediate working memory load), or a six-letter target (high working memory load). As Figure 3 demonstrates, these investigators found that performance on tasks characterized by a low working memory load was indeed correlated with the body temperature rhythm, while those tasks with an intermediate memory load had no correlation with body temperature. In addition, tasks which had a high memory load were actually negatively correlated with the temperature rhythm.

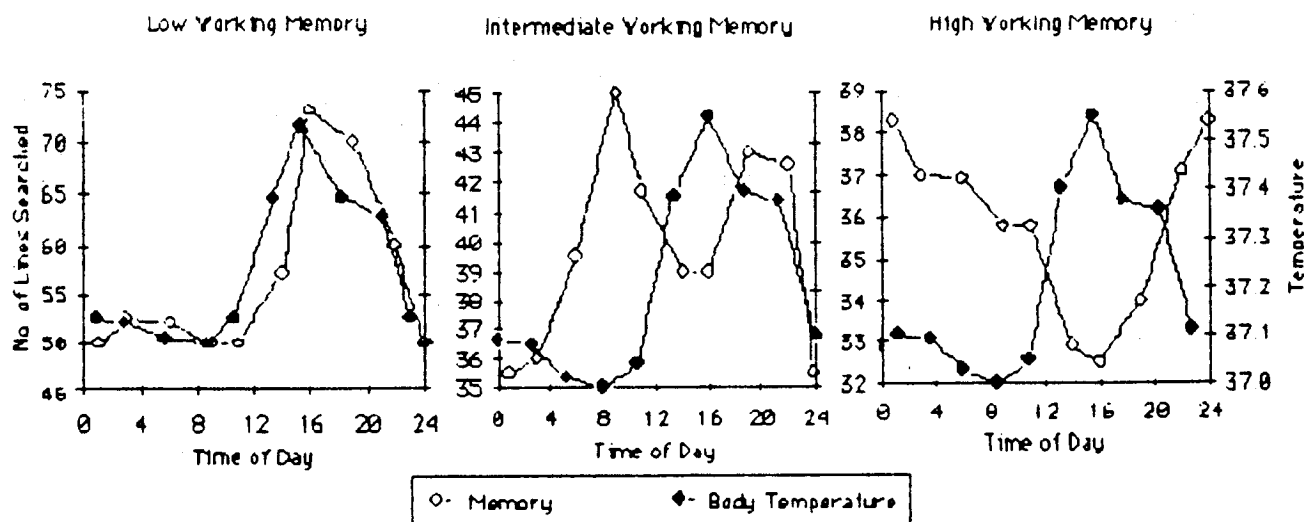


Figure 3. Time of day effect on low, medium, and high working memory load versions of a visual search task together with that in body temperature. After Folkard et al. (1976).

This study suggests that different types of tasks are performed at different levels of proficiency during the waking day, regardless of the actual time of day, and that it should be possible to predict from physiological changes in the body when these peaks and troughs in performance will occur. This being the case, it should follow, then, that it is possible to schedule work in selectively loaded tasks or activities accordingly.

Monk and Leng (1982) studied human performance on simple repetitive tasks which required little or no working memory over the waking day (diurnal rhythms). Their concern was with how the speed and accuracy of serial search task results were affected over a specified time period. They found that as the waking day progressed, accuracy on the task decreased while the speed at which the task was completed increased. The authors generalized their data and concluded that there is a tendency for people to perform simple, repetitive tasks more quickly but less accurately as the day wears on. Monk and Leng furthermore assert that this increase in speed and decrease in accuracy may be mediated by the amount of information processed and not solely by the speed at which the information was processed as was previously hypothesized. The implications to be drawn from this study are that those tasks which require significant attention to detail and are of a critical nature should probably be scheduled early in an individual's waking day when he/she usually performs most accurately.

In a study concerned with how individuals differ with respect to circadian rhythms of activity and how these differences might affect interpersonal relationships, Watts (1982) suggested that as the differences in circadian activity rhythms of individuals who live together increase, the more probable there are to be problems with the relationship. Circadian activity rhythms are defined in this investigation as the cycles of time of day that the individual both feels and performs best. Problems in the relationship include not liking being together, not getting along well, not wanting to continue living together, not feeling very close in their friendship, etc. Also, using Horne and Ostberg's (1976) Morningness-Eveningness Questionnaire, Watts suggested that people may be categorized as either Morning-types or Evening-types, and that Morning-types may be more task orientated. Certainly, this study indicates that circadian activity rhythms are an important factor when considering interpersonal relationship within a confined space for an extended period of time.

Borowsky and Wall (1983) studied Naval aviation mishaps as a function of fatigue, both physical and psychological, and found support for the hypothesis that circadian desynchronization contributes to mishaps. The authors concluded that pilots who

had performed duty during at least 10 of the last 24 hours prior to take off were significantly more likely to be at fault in a mishap. The inferences from this study are that if sleep occurs at times other than that normally scheduled, then sleep quality and quantity will probably be impaired and resultant behavioral and psychomotor decrements will probably occur. This particular problem will be discussed in greater depth in a later section.

In their review of the literature, Folkard and Monk (1983) brought to light several important considerations. They reported that even if individuals are sleep deprived, their other physiological rhythms maintain their regular rhythmic fluctuations. When this happens, rhythms may become desynchronized and occur at different time periods; e.g., the body temperature rhythm may have a period of 25.1 hours while the activity rhythm may have one of 33.4 hours. As a result of this desynchronization, performance on various tasks suffers. The authors also hypothesized that performance on memory-loaded cognitive tasks may be under the control of an oscillator which is entirely different than the one that contributes to the sleep/wake cycle. Folkard and Monk also suggested that the resultant decrement in performance measures as a consequence of dysrhythmia or desynchronicities is approximately ten percent. While a ten percent decrement in performance may not spell disaster for a given mission, it may preclude complete success, suggesting that the causes for this decrement should at least be considered when conducting or scheduling various missions or tasks.

Folkard et al. (1983) used Wever's (1983) "fractional desynchronization" technique to separate various rhythmic patterns. This is accomplished by artificially shortening or lengthening a subject's "day" without his knowledge. This is usually accomplished in a laboratory in the absence of naturally occurring zeitgebers on which individuals depend, and simultaneously introducing artificial zeitgebers which provide false and misleading information. As a result of this altering of environmental cues, internal desynchronization results and the normal sleep/wake cycle (which is usually very closely tied to the temperature rhythm) separates from the body temperature cycle and each then runs with its own distinct period. When this desynchronization occurs, other performance rhythms may also separate and run their own periods. Folkard et al. reported that the demands of the task itself may affect how rapidly performance rhythms adjust to changes of the sleep/wake cycle. They concluded that performance on non-memory loaded tasks is controlled by the same oscillator that regulates body temperature, while highly loaded memory task performance is under the control of a different oscillator and has a 21-hour period. Again, it would seem reasonable to conclude that the systematic scheduling of different cognitively loaded tasks at different times of the waking day could effectively enhance performance

measures.

In their search for ultradian rhythms in human cognitive functions, Bossom, Natelson, Levin, and Stokes (1983) concluded that there are in fact specific, predictable, ultradian rhythms in visuo-motor performance on specified tasks, and that there are specific rhythms of recall abilities as well. The behavioral tasks these investigators used included a test of non-verbal recall (short-term memory) and another of eye-hand coordination. It was found that the period of each of these cycles appeared to be approximately 90 minutes, although there were notable and varied individual differences in the length of these periods. The implication here is once again that performance on certain specified tasks is rhythmic and predictable and this information should be helpful in the scheduling of tasks.

Colquhoun (1984) studied the effects of transmeridian flight on personality and body temperature. He employed the Heron Personality Inventory (Heron, 1956) to discriminate between introverts and extroverts. Both body temperature and mental agility (arithmetic calculations) were measured for ten days following an aircraft flight crossing eight time zones and lasting for 21 hours. It was reported that body temperature remained elevated following the flight but that performance on arithmetic tests showed a decrement. The researchers also found that introverts showed more physiological disruption after these flights as well as greater deficits in mental performance. It was concluded from this study that the loss in mental efficiency is directly related to the disruption of physiological circadian rhythms following the transmeridian flight. One implication from this study is that it should be possible to predict, at least partially, the degree of rhythmic disruption in physiological circadian rhythms following a time zone change from the scores obtained on a standardized personality inventory.

Monk, Weitzman, Fookson, & Moline (1983) confirmed earlier findings that there is not always a direct correlation between the circadian rhythms of performance and that of body temperature. They reported that performance on verbal reasoning tasks (highly cognitively demanding requirements) depends on an oscillator which has a 21-hour period and is distinctly different than the body temperature rhythm, while performance on manual dexterity tasks seems to be tied directly to only the temperature rhythm. Later, this same group of investigators (1984) confirmed that indeed the performance of different types of tasks is under the control of different oscillators. For instance, the circadian characteristics of cognitive verbal reasoning tasks and more simplistic behaviors or tasks which involve manual dexterity are vastly different, with verbal reasoning displaying a much shorter rhythmic period than the others. This study provides further evidence that there is not a single performance rhythm, but several.

Winget et al. (1984) reported that dysrhythmia, while serious, is in and of itself not life threatening, since it did not result in the demise of the three females and over 150 males who survived periods of up to 185 consecutive days in the space environment. They also reported that subjects with small amplitudes in body temperature rhythm (measured as the amount of change) show less resistance to phase shifts (unusual work/rest scheduling, transmeridian flight, etc.). This finding indicates that it should be possible to determine which individuals would be most adversely affected by changes to their daily routines. According to a Russian investigation cited in Winget et al., (Stepanova, 1977), individuals who exhibit circadian rhythms that are less stable in time than other individuals would experience less difficulty adjusting to altered sleep/wake cycles and would therefore make better candidates for space missions.

From an investigation designed to determine the relationship between the alertness rhythm and the sleep/wake cycle, Folkard, Hume, Minors, Waterhouse, and Watson (1985) concluded that the alertness rhythm in humans can run independently of the sleep/wake cycle and can become separated from the temperature cycle as well. This study implies that the circadian rhythm in alertness is a "purer" reflection of the strong endogenous oscillator mentioned earlier than is the body temperature rhythm. It is also a possibility that this alertness rhythm is controlled by a different oscillator than the one that controls the temperature rhythm, and that core body temperature may not always be a reliable predictor of alertness in humans.

Shift Work and Human Performance

Future space stations and, indeed, even long duration space travel itself may necessitate the introduction of working differing shifts to maximize the productivity of a limited number of personnel and the limited resources in those particular environments. Unfortunately, human performance is known to be affected by altering work schedules, and circadian rhythms and their influences on behavior and performance should certainly be considered prior to assigning either the type of work to be accomplished, the type of shift system to be employed, or the individual involved in working on the particular system selected for use.

Folkard, Knauth, Monk, and Rutenfranz (1976) reported on the performance of subjects who were exposed to a rapidly rotating shift system. This particular system involved working two days on the morning shift, followed by two days on the evening shift, and ending with two days on the night shift. The task they

examined could be varied in the amount of memory and cognitive processing required to successfully accomplish it. The experimenters found that when the low-memory-loaded version of the test was employed, performance showed a highly positive correlation with body temperature and was consequently poorer when accomplished during the night shift. However, when the high-memory-loaded version of the test was used, performance was negatively correlated with temperature and was best during the night shift. These researchers concluded that the circadian rhythm of performance on a given task depends both on the short term memory load involved in the successful accomplishment of the particular activity, and its relationship to other primary oscillators or rhythms.

Folkard and Monk (1979) studied shift work and performance to determine why performance on night shifts is slower, less accurate, and more accident prone. The investigators concluded that the degree to which a worker's rhythms adjust to changes in working or resting hours is central to the problem of impaired efficiency. They also reported that, "...where the cost of an error may be extremely high (e.g., a large chemical plant), a permanent shift system should be used, and that members of the night shift should be dissuaded from reverting to a day-oriented routine on their rest days" (p. 485). This is true because the circadian rhythms of these workers would be in a constant state of flux, never having enough time to completely adjust to the new schedule before it was changed yet once again. They also reported that performance on verbal reasoning tasks responded to changes in schedules faster than perceptual-motor tasks. This indicates that more cognitively loaded tasks are degraded for a shorter amount of time than are strict psychomotor skills when hours of work are altered.

Buck (1980) studied performance rhythms among workers in the Arctic where the sun did not rise or fall for large parts of the year. In this environment, it is always light during the three summer months and always dark during the three winter months. He found that it was possible for people to maintain their normal performance rhythms in customary 24-hour work patterns even though solar light-dark cues were absent. Hence, it is possible that traditional zeitgebers such as solar time cues can be altered if other meaningful ones (especially social ones) remain present without a consequent performance decrement.

Reinberg, Andlauer, Guillet, Nicolai, LaPorte, and Vieux (1980) studied possible correlations between the circadian rhythms of body temperature and a worker's tolerance to shiftwork. These investigators found that subjects who are tolerant to shift work over many years (meaning that they had suffered no medical problems as a result of changing shifts) are likely to have a large amplitude in circadian temperature rhythms (measured as amount of change), and that these workers will probably adjust slowly to new schedules. These experimenters

conclude that circadian rhythm amplitude should be a reliable index of long-term tolerance to shift work.

Many studies have been conducted for the purpose of determining which shifts prove most advantageous in terms of both worker satisfaction and productivity. Most shift work schedules today involve phase advancing (from nights, to evenings, to day shifts), and most rotate rapidly, with only seven days per shift. Czeisler, Moore-Ede, and Coleman (1982) found, however, that both worker satisfaction (measured via questionnaire) and productivity (measured as the rate of potash production) increased significantly when workers were shifted to a phase delaying, slow rotating (21-day) shift system which takes advantage of human circadian properties. This information could be useful in determining the most efficient scheduling of duty days.

In a similar study, Ward and Stobbe (1984) found that shifts rotated from the morning, then to the afternoon, and finally to the evening shift (phase delay) resulted in less circadian disruption and that when coupled with a slow rotating system (21-day) increased both worker satisfaction and productivity.

Minors and Waterhouse studied shift workers and were concerned with the ability or inability of certain workers to adjust physically and psychologically to working at differing times of the day (1983). Previously, the personality of the worker, the amplitude of the workers' circadian rhythms, and the phasing of these rhythms had all been implicated as having some predictive value in determining who would adjust most easily to shift work. In an attempt to add further evidence to the validity of some of these predictors, the experimenters conducted their own investigations and concluded that the commitment of the worker is a very important variable and that circadian rhythms of a high amplitude may be a consequence of a regular sleep/wakefulness cycle and not a predictive variable which reliably determines which workers would be successful as shift workers as was previously believed.

Colquhoun (1985) studied various 24-hour shifts being used on board ocean-going vessels. In his review he compared stabilized and rotating shift work and concluded that, "...rotating systems have little, if anything, in their favor, since adjustment to them is impossible, and, if followed for any length of time, rhythm disintegration may ensue" (p. 651). The investigator advises a stabilized system for ocean-going vessels, and it would seem logical to advise the same type for long duration space missions.

Moore-Ede and Richardson (1985) assessed the medical impacts of shift work and listed sleep/work disorders, gastrointestinal,

and cardiovascular disorders as probable outcomes of shift work to some individuals. They also recommend stabilized systems or, as an alternative, systems which rotate less frequently (i.e., 21-day as opposed to 7-day rotations).

In the same light, other researchers have pointed out the advantages of fixed shifts. Socialization, mental health, and job satisfaction were notably higher in fixed shift as compared to rotating shift workers (Frost and Jamal, 1979), and on-the-job performance is also higher for fixed shift workers (Jamal, 1981; Jamal and Jamal, 1982).

Conclusions

The information in this section has been gathered from studies performed in the earth environment, free of the unknown influences of the space environment. As a result, the generalizability of the findings is always somewhat questionable, and it is the first recommendation of this paper that generalizability studies be conducted in this arena. Secondly, many of the conclusions drawn are based on single studies, the reliability of which have yet to be determined in replication work. Nevertheless, the conclusions made and the considerations offered here are the author's best attempt to lend an operational flavor and application to this information as it might be used in planning for long duration space missions.

It is also important to remember that the decrements in performance as a result of dysrhythmia or circadian disruption are on the scale of approximately ten percent and that the motivation of the individuals involved may change this percentage, at least in the short term. Indeed, Soviet scientists reporting on the status of the cosmonauts involved in the Salyut-6 space station reported that "the prolonged space missions did not cause any serious psychological problems which could interfere with crew work or lead to psychosomatic disorders" (Vorobyov, Gazenko, Genin, & Egorov, 1983). However, it is also well to remember that a ten percent decrement in performance on some tasks could very well result in unacceptable consequences, or make the difference between success and failure. The following considerations are offered as possible steps which could be taken to offset some of the ill effects of dysrhythmia.

Various rhythms have been identified which follow fairly regular cycles. Further, these cycles (or cyclic rhythms) seem often to be systematically related to certain performance phenomena, and thus the biological rhythms may be used to predict individual performance under certain conditions.

Attention to detail is greatest early in the waking day; ie., soon after the individual wakes up, regardless of the actual time of day. Later in the waking day the tendency is to perform tasks faster, but less accurately. CONSIDERATION: Perhaps those tasks which require the most attention to detail should be scheduled earlier in the worker's waking day, regardless of the actual time of the day.

There are individual differences in circadian rhythms, and tests exist which can determine an individual's propensity to be a morning or evening person. CONSIDERATION: Astronauts should be matched with others who share similar propensities, or scheduled on opposing shifts with those who differ significantly in their propensity.

Desynchronization impairs performance in aviation. CONSIDERATION: Altering or disrupting circadian rhythms initially results in decreased performance and increased error rate. Attempts should be made to avoid desynchronization.

Short-term and intermediate memory usually decline over the waking day, while long-term memory abilities increase. CONSIDERATION: One-of-a-kind type tasks (experiments and projects) should be scheduled early in the waking day, while more routine tasks be scheduled later. In addition, tasks requiring high cognitive ability (mental processes) should be accomplished early in the waking day. For a more comprehensive discussion of circadian rhythms and human memory, see Matthews (1987).

Introverts are affected to a greater extent in mental performance and physiological adjustment than extroverts. CONSIDERATION: Perhaps personality inventory results in introversion/extroversion scales should be considered when selecting astronauts for long term space missions or assigning them to work schedules with others.

Studies confirm individual variation in stability of circadian rhythms. CONSIDERATION: Individuals who normally show greater variability in their rhythms may adapt to disruptions with greater ease and would perhaps make better candidates for long duration missions.

When the cost of an error may be critical, a permanent shift system should be employed. Research has shown that rotating shifts have little if any benefit since they lead to rhythmic disintergration. CONSIDERATION: Workers on each shift should follow a consistent work, leisure, and rest routine and shifts

should be stabilized. Stabilizing shifts avoids problems with sleep/wake, gastrointestinal, and cardiovascular disorders, while promoting mental health and job satisfaction.

Zeitgebers are external synchronizers for circadian rhythms. In space the usual dark/light cues will be altered. CONSIDERATION: Attempts should be made to keep as many zeitgebers as possible consistent with normal wake/sleep cycles.

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CIRCADIAN VARIATIONS IN HUMAN MEMORY: IMPLICATIONS FOR CREW PERFORMANCE ON EXTENDED SPACE MISSIONS

MICHAEL D. MATTHEWS

The role of the human element in space flight is becoming increasingly important as space missions gain in complexity and as the duration of missions is extended. Previous research on this topic centered on examining results from empirical studies of environments analogous to space on the dimensions of isolation, confinement, and harshness. Variables examined included ergonomic issues of crew habitability (McCloy, 1985), circadian rhythms (Kanus & Feddersen, 1971; Matthews, 1985), and social aspects of the human sub-system (Wood & Dunivin, 1985). The purpose of the current paper is to consider the effects disruption of memory --- a central concept to information processing models of human performance --- might have on crew performance on space missions of durations of three months or more.

MEMORY AND INFORMATION PROCESSING

Wickens (1984) details a model that conceptually describes the components of human information processing and how these components interact. The major subsystems of information processing, according to this view, are short-term sensory store, perception, decision and response selection, attention, and memory. Response execution is dependent on the functioning of and interactions among these subsystems. Memory is thought to consist of both long-term store and working memory. Both forms of memory are vital components of the overall system, and strongly influence response outcomes. Since memory is affected by perception and vice versa, and because it is also impacted by attention, it is often difficult to tease out the unique contributions of memory in information processing. Nevertheless, when interpreting the literature reviewed below, one should remain cognizant of the general impact memory disturbances can have.

CIRCADIAN DISRUPTIONS IN MEMORY

A. Long-term Memory

Long-term (LTM) memory generally refers to retention intervals of 30 seconds duration or longer (Spear, 1978). Most empirical studies of memory have examined retention intervals of a few minutes to 24 hours, and a few have been reported for intervals greater than one week (Bahrick, 1985). While most studies of circadian (i.e., 24 hr) disruption of memory are laboratory-based, the results of some field studies are also reviewed here.

Baddeley, Hatter, Scott, and Snashall (1970) examined the effects of time of day on long-term memory using Hebb's repeated digit technique. It was found that time of day had no significant effect on long-term memory as assessed by this measure. However, in retrospect, Baddeley et al. questioned whether or not the Hebb technique really involves long-term memory, and concluded that it may not. Hockey, Davis, and Gray (1972) also looked at time-of-day effects on recall from long-term store. The authors administered a more traditional verbal free recall task to a sample of female undergraduate students at either 0400, 0630, 1130, or 2300 hrs. Five hours following administration of the material, recall was tested. Results indicated that subjects trained at 2300 and 0400 showed decrements from initial training performance levels to the recall test of 22.8 and 34.5 percent, respectively. In contrast, subjects trained at 0630 and 1130 showed recall decrements of 43.0 and 46.9 percent, respectively. Thus, LTM was best for subjects trained late in the day (i.e., 2300) and poorest for those trained in the morning hours.

This pattern of better long-term memory for material learned later in the day has been found in a variety of situations and with a number of different recall tasks. For example, Folkard, Monk, Bradbury, and Rosenthal (1977) tested for recall of verbal material over a delay of one week. Material was presented to 130 male and female 12- and 13- year old students at either 0900 or 1500 hours. Material learned at 1500 hours was recalled significantly better than material learned earlier, regardless of the time of day the recall task was administered. Similarly, Folkard and Monk (1980), studying LTM recall over a 28-day retention period, and Tilley and Warren (1983), using adult women subjects and a more complex semantic classification task, corroborated the observation that long-term memory improves for material learned later in the day.

Just why long-term memory improves with time of day is still somewhat uncertain, but one hypothesis that may have merit is that performance on this and other complex cognitive tasks follows the circadian curve for arousal, which also peaks in most people later in the day (Kleitman, 1964). A simple physiological correlate of human arousal is body temperature, which consistently follows a pattern of increasing gradually through the day, peaking just after bedtime, and dipping to its lowest point between the hours of 0300 and 0500. It is also worthy of note that performance on most complex and/or memory-loaded cognitive tasks tends to peak later in the day (see Winstead, 1987).

B. Short-Term/Working Memory

Short-term memory (STM) refers to retention intervals of less than 30 seconds, but should be differentiated from sensory memory (the store retaining physical stimuli for possible further encoding), which is more automatic and involves durations of 2 seconds or less (see Wickens, 1984, for further clarification between short-term and sensory memory). Recent cognitive literature contains no mention of any study of sensory memory as a function of time of day or circadian variations, so it will not be covered in this review. Nevertheless, it must be suggested that circadian variations in sensory memory are a potentially important factor in predicting human performance in extended space missions, as disruptions of the initial sensory input into the information processing system should have significant effects on overall task performance.

Another form of memory that may be viewed as a type of short term memory is working memory, which refers to an active and dynamic memory store that draws upon both short - and long-term stores. Although Wickens (1984) includes it as a component of his information processing scheme, working memory is not universally differentiated from other forms of human memory by psychologists, and hence will not be treated as a separate topic of this review.

The empirical data relating effects of time of day or circadian rhythms to recall from short term memory consistently indicate that STM is best relatively early in the day, and decreases in efficiency as the day progresses. That is, its pattern is the opposite of that of LTM. For example, Baddeley et al. (1970), in their study of memory reviewed above, also examined time of day effects on a digit recall STM task. STM performance was consistently better at 0930 than at 1500. Hockey et al. (1972) also found that STM for immediate verbal recall was superior for all morning recall groups. This superiority was accounted for by enhanced primary memory performance, as indicated by thorough analysis of serial position effects. Numerous other studies have found a similar pattern of results (e.g., Folkard, 1979; Folkard & Monk, 1980).

One last study bears reporting because it suggests that in addition to circadian rhythms in memory, there also exist shorter, or so-called "ultradian" patterns of performance. Bossom, Natelson, Levin, and Stokes (1983) studied seven adult males on an STM nonverbal recall task. Analysis of results indicated that each of the subjects showed reliable rhythms of about 90 minutes duration throughout the day, in addition to the general decline in performance as the day progressed noted by other researchers. These fluctuations further complicate the large picture of predicting and controlling human behavior, especially if they can be disrupted in confined or ambiguous environmental conditions, as is likely the case.

IMPLICATIONS FOR EXTENDED SPACE FLIGHT

As Derrick (1985) points out, generalizing the results of laboratory-based studies of human behavior, or even those done in analogue environments, to human performance in the actual space environment is always a tricky business. In evaluating the literature on memory, three questions may be asked: (1) are there circadian variations in human memory; (2) if so, what is their nature and magnitude; and (3) what possible impact might these variations have upon overall human performance and mission effectiveness under the conditions of long duration space flights that are the focus of this report?

The first question can be given a fairly straightforward reply. Circadian variations in human memory do exist. The theoretical interpretation of these variations is still being debated by psychologists, however. The second question can also be answered directly: STM is better in the morning and LTM in the afternoon. Of course, this applies to persons on "regular" sleep/waking cycles. The extent to which these findings will generalize to individuals in chronically interrupted sleep-wake patterns has yet to be investigated. Moreover, the magnitude of the fluctuations is fairly substantial, ranging in the neighborhood of 15 to 20 percent in most cases, and as much as 50 percent under some conditions.

The response to the third question is more speculative in nature. Based on earlier reviews of the more general topic of circadian rhythms of human performance in confined and isolated environments (Matthews, 1985), one can safely conclude that major variations occur in human behavior in the broad sense (cognitions, emotions, social relationships) under these conditions. Other papers include in this report substantiate this fact. It is also known that memory is a key component of human information processing, and any disruptions that occur in memory have a deleterious effect on decision making in general.

In evaluating the impact of these likely disruptions of human memory, both STM and LTM, consider the following two scenarios. Scenario I involves a long-duration orbital mission, which is proceeding in a nominally successful fashion. Routines are quickly established on board. Crew members, who are well trained and whose group affiliations are cohesive, adapt to their new physical and social environments. The impact of memory disruptions under these conditions is likely to be minor, and similar to those experienced by workers on earth who suffer circadian disruption. That is, on repetitive and simple tasks, crew members should have little difficulty. On more complex tasks, access to memory will be poorer, requiring additional time to recall material or to look up information in technical manuals or other sources. Work on these tasks may thus be slowed, but it will be accomplished.

Scenario II is quite similar to that described above. Things are progressing routinely, and have done so for many weeks. Suddenly, however, an emergency situation arises (perhaps an onboard explosion, an impact with debris, or a major systems failure) which requires immediate and highly accurate responses to save the mission. No amount of crew selection or training can eliminate circadian rhythms or their disruption in ambiguous environments because these responses are a normal biological phenomenon in the human species. Under such emergency conditions, the memory-based performance decrements, and their impact on perception, attention, and decision making, could readily decrease the likelihood of the crew responding quickly and accurately enough to overcome the problem, and attendant mission setbacks or failure are now a likelihood.

Thus, the bottom line with regard to the implications of memory disruptions upon crew performance is that "it depends". If all else is going routinely, the impact should be relatively minor. But in the event of a situation requiring emergency response and maximum cognitive function, the mission could be impacted quite adversely.

POSSIBLE PREVENTIVE MEASURES

Little or no research has been done directly addressing the question of how to minimize circadian variations in memory. However, a substantial body of work has looked at ways of inoculating people against the general behavioral and emotional effects of circadian disruption. In 1985, for example, the Division of Neuropsychiatry at Walter Reed Army Institute of Research published a comprehensive annotated bibliography (WRAIR, 1985) on human performance under conditions of sustained operations. This bibliography contains full references to a variety of work done in the domain of ameliorating effects of circadian disruption. While a complete review of this information is beyond the scope and tasking of the current paper, several points may be made.

First, napping may offset to some degree disruptions of human performance brought about by lack of sleep or disturbed sleep (e.g., Naitoh, Englund, & Ryman, 1982). Even when regular sleep patterns are maintained, other indexes of performance may be distorted under conditions of confinement and altered environmental cues. Naitoh, Beare, Biersner, & Englund (1981), for example, found that submarine crews ultimately developed desynchronization of oral temperature and mood, even when sleep was fairly regular. Napping, even in non-sleep-deprived subjects, might minimize these effects, although this notion has not been tested to date. Most of the studies reviewed examined naps of relatively short duration, i.e., 15 minutes or less. One problem with napping that should be noted is that for a few minutes immediately following a nap, performance on many measures may actually be decreased in comparison to pre-nap levels. This decrement is followed rather quickly by an elevation in performance, however.

Other tactics have been suggested to minimize circadian disruption of performance. Relaxation techniques such as biofeedback and meditation, drugs, meal-timing, careful scheduling of work/rest cycles and rearrangement of social and recreational schedules may be used to this end (see Matthews, 1985). However, the majority of the research in this domain has been laboratory - based, and no studies have been done in the long duration space mission environment, so the utility of these methods as applied to the astronaut corps in an operational setting must be investigated.

The most prudent approach mission planners might take at this point would be to sponsor basic research on the effects of confinement and environmental ambiguity upon a sample of subjects more similar to past crews, in settings designed to closely simulate conditions in space. This could be done on a training "mission" and relatively unobtrusive measures of cognitive performance could be gathered. Such information would clarify the degree to which human information processing is indeed disrupted on extended space missions, and suggest the extent to which measures designed to minimize these effects should be explored. In addition, further investigation of circadian effects on sensory memory seems warranted, albeit somewhat beyond the scope of this paper.

SUMMARY AND CONCLUSIONS

Some disruption of human memory may be expected during extended space missions. Ordinarily, in the earth environment, STM is better early in the day, and LTM later in the day. Under conditions of altered environmental cues and confinement, these normal rhythms will be affected, and a variety of human information processing skills, including memory, may be adversely impacted. The magnitude of this impact on memory will likely be on the order of 15-20 percent loss of efficiency from baseline. Moreover, the operational cost of these and related changes in information-processing speed and accuracy probably will depend on the particular mission scenario in terms of their impact upon mission effectiveness. However, suggestions for ways to inoculate crew members against these effects rely on additional basic research.

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THE INTERACTION BETWEEN PERSONALITY AND THE SPACEFLIGHT ENVIRONMENT

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Man has successfully reached numerous milestones in space exploration. Astronauts and cosmonauts alike have handled the many challenges of manned space travel with competence. Incredible technological efforts have been poured into these missions, yet the interpersonal and behavioral considerations regarding the astronauts themselves have received minimal attention and published research in this country (Santy, 1983). Luckily, downplaying psychological issues has apparently had no serious consequences for the United States' space program to date, although it could be argued the Challenger disaster was a malfunction of human decision-making strategies (Kruglanski, 1986).

The men sent into space seem to have been as psychologically qualified as they were technically and physically qualified. Will our successful track record hold for a long duration space flight? Possibly. Given the incredible stakes in terms of effort, money and human lives, however, we should examine the interaction of men and the spaceflight environment using current information and analytical skills to suggest better ways of understanding and predicting the relationship and possible outcomes.

Psychology has several branches and each focuses on different aspects of human behavior. A recent, promising development is a blend of several approaches called the "interactionist" position, which acknowledges the importance of personality dispositions as well as the role of situations in influencing behavior (Bandura, 1986; Endler and Magnusson, 1976). It states, simply, that the individual and the environment are not separate and cannot be considered separately. Instead, there is a continuous dynamic interaction between the two factors. Admittedly, it is complex to study individual factors, such as personality variables, the cues in a situation salient to that individual, and also how the individual and the environment trigger changes in each other. However, human beings are complex, and thus an effort needs to be made to organize and simplify these complex concepts.

The two interacting elements of person and situation are also central to the concept of "stress." Stress has been defined as the product of a person's appraisal of a situation and his ability to respond to its demands. The effect of stress therefore depends on the demand made on the adaptive capacity of the person (Selye, 1974). Only if the person feels overwhelmed by these demands does stress have negative effects. Every astronaut and cosmonaut that has been in space has experienced stress. Each and every one of them has apparently been competent in meeting these demands, although there is at least one instance (Cooper, 1976) where astronauts insisted on renegotiating task demands.

This chapter presents a preliminary interactional analysis of personality traits and the space environment during previous and future space missions. The first section will examine the current and past spaceflight environment, the personalities of previous astronauts, and the resulting interactions. Both the Soviet space program and experiences in other isolated, dangerous environments (such as submarine travel or wintering over in Antarctica) are then discussed. The process of stress is described, as are stress-resistant personalities and coping techniques. In the next major section, six personality traits are defined and described, the future space environment is discussed, and the projected interaction between personality and environment is analyzed. Conclusions and considerations for future spaceflight are presented in the final section.

THE SPACEFLIGHT ENVIRONMENT

What is the daily environment that faces the inflight astronaut? An environment can be analyzed using the following criteria: (1) the physical or ecological dimensions; (2) the tasks or behaviors to be performed; (3) the characteristics of other environmental inhabitants; and (4) the organizational structure and climate.

I. PHYSICAL DIMENSIONS

The physical characteristics of spacecraft have been extensively examined and compared to Earth-like environments by other researchers. Such craft were designed to meet minimum standards of human acceptability (McCloy, 1985, discusses these issues) in terms of spatial dimensions, lighting, temperature, and so on. When equipment malfunctions, however, space vehicle inhabitants cannot escape the immediate physical environment. For example, Skylab I initially suffered an energy shortage and the astronauts conserved energy by only using light in the immediate work area (Cooper, 1976). One astronaut complained this made him feel "like a mole".

The architecture onboard a spacecraft differs markedly from familiar earth configurations. For example, Skylab astronauts were more comfortable on the lower deck, presumably because the lower ceilings and smaller areas resembled a typical apartment on Earth. Sleeping in a weightless environment is strange, since restraints are needed. The Skylab astronauts slept in a vertical bag similar to a cocoon (Cooper, 1976). Sleeping itself may be more difficult due to a lack of time cues, such as sunrise or sunset (see Matthews, 1985).

Crew movement of any kind (even eating or voiding) is complicated by weightlessness. Food is dehydrated, bland, and seems to have no odor, due to head congestion in microgravity. Inability to smell, however, is fortunate since clothing is worn continuously before disposal and showers are rare and troublesome in weightlessness. The amount and types of stimuli in the immediate environment to arouse or calm crew members is limited (Austin, 1987) and crew members are confined in small areas.

Effective interpersonal communication between astronauts is complicated by two simple facts. First, sound travels only a short distance in microgravity. In addition, inhabitants cannot use facial cues during conversations because faces puff up considerably in zero gravity.

II. TASKS

The tasks that have been and will be performed by astronauts vary from mission to mission. However, these tasks have frequently been characterized by time constraints, high visibility, performance pressure, and limited autonomy. One of the better examples of both extreme visibility and limited autonomy occurred during Skylab III. One astronaut vomited. According to regulations, the crew should have freeze-dried the vomit for medical analysis. Instead, they threw it down the trashlock, unaware they were being recorded. The crew was reprimanded publicly (Cooper, 1976). The lead flight director in charge of the Skylab missions had said, "We prided ourselves here that, from the time the men got up to the time they went to bed, we had every minute programmed....You know we really controlled their behavior" (Cooper, 1976; p. 129).

For inflight problems, astronauts do have some autonomy. For example, Skylab crew members fixed storage batteries, the air-conditioning system, and several cameras. With major problems, however, crews were given explicit instructions. (Any serious problems, such as the solar panel malfunction aboard Skylab I, were closely monitored. Ground crews simulated in-flight problems so that instructions could be relayed, as cited in Cooper, 1976.)

The experiments sent on space flights were designed by a scientist who was not on board. The person(s) expected to perform the experiment may have had limited task competence. Locating experimental equipment was also difficult. Because of zero gravity, equipment must always be securely stowed. For example, forty thousand items were stashed away in over a hundred cabinets on Skylab. The Skylab III astronauts complained that items were not stored according to records or even logic. Although six men and a computer in Houston were devoted to keeping track of space station items, the system was useless because earlier crews failed to report where they put things (Cooper, 1976). This type of situation exacerbates the performance decrements of even the simplest tasks.

High workloads have characterized all of the U.S. space missions, even those of shorter duration. The astronauts of Skylab, in particular, had a very heavy workload and little spare time (Helmreich, Wilhelm, and Runge, 1980). No astronaut finished more than one book during the 84 day mission. And, of course, it was the Skylab III crew who called a moratorium until mission control decreased workload and performance pressure (Cooper, 1976). According to Gerald Carr, the commander, only those tasks which had to be accomplished at a specific time (perhaps due to spacecraft orbit), remained on the schedule. The astronauts therefore had more autonomy in performing tasks. With pressure reduced, the astronauts were more productive (Carr, 1985).

When and if space travel becomes more mundane (or at least better funded), the personnel aboard may routinely have more independence in what they choose to do and how and when they choose to do it, and also may not be watched and evaluated so closely. The tradeoff is that many job tasks may then become repetitious and unexciting, particularly if performed over an extended period of time.

III. OTHER INHABITANTS

Flight crews, from Mercury through Skylab, were remarkably homogeneous in both background and training (Bluth, 1978). All were full time, high status NASA employees, male astronauts with military backgrounds, flight training, and EVA capabilities (spacesuit qualified). They had trained together over a long period of time and so were relatively cohesive (Bluth, 1978). From Mercury to Apollo, crew size ranged from one to three persons, and Skylab was always manned by three individuals. During the three Skylab missions, one of the trio was always a "science pilot," the first example of crew non-homogeneity. However, the scientists were trained with the military men, which minimized possible conflicts (Cooper, 1976).

With the advent of the Shuttle missions, the crews diversified. There were now four categories of crew members: mission specialists, payload specialists, and principal investigators (scientists), along with the flight-trained astronauts high in the mission command hierarchy (Bluth, 1978). (These categories do not include one-time crew members serving a PR function such as teachers, a practice likely to be suspended after the Challenger disaster.) Training differed between categories and primary and backup crews were not assigned to specific missions beforehand. The mission commander and the pilot were trained with full astronaut status. The mission specialist had astronaut status but was not pilot-trained. Payload specialists were trained in space safety for approximately one year, were not pilots, and were not spacesuit qualified (Bluth, 1978). The training given principal investigators varied, but they were neither pilot nor spacesuit qualified. Women were included in the crew, as were individuals from other backgrounds (such as the Canadian Navy Commander Marc Garneau on Shuttle Mission 41G in October of 1984). The ground crews have been even more diverse, although efforts have been made to have fellow astronauts and physician-astronauts as communicators in mission control.

Whether spaceflight crews are homogeneous or not, they are forced together. They are packed into a small physical area whose configurations are primarily dictated by mission constraints. Privacy is nearly impossible and a crew member can have little time off from his/her supervisor, and vice versa.

The crew is also subject to social isolation or estrangement (Berry, 1973; Kubis, 1972). Members can be separated by over a quarter of a million miles or for lengthy periods of time from their families, friends, peers, and enemies, and the fulfillment of needs previously met by these relationships. Both mission control and fellow spacecraft inhabitants then become the primary support group for the crew. It may be difficult, however, for the same group to provide both work evaluation and nonevaluative support (Bluth, 1982).

IV. ORGANIZATIONAL STRUCTURE AND CLIMATE

All space missions have been characterized by a definite vertical, military command structure. Mission control supervises the command pilot, who is responsible for crew performance/behavior and the attainment of mission objectives. Mission objectives have been clear and spacecraft personnel were very familiar with this type of chain of command. Any problems with authority have been disagreements between earth-based control and on-board crew personnel (Helmreich et al., 1980). Friction between crew members was not expected to occur, since mission accomplishment was paramount. Personal problems, such as marital strife, were also not expected to influence in-flight performance. Dedicated professionalism from a military perspective was the expected norm.

NASA as an organization places a very high value on achievement. Astronauts were, and are, expected to accomplish a great deal to demonstrate how effective men could be in space (Cooper, 1976). For example, the Skylab III astronauts were suffering from insomnia by the end of the first week. Their workload was then increased by the lead flight director (because they were lazy? to tire them out?) at the beginning of the second week (Cooper, 1976).

The in-flight environment itself contained work behavior cues exclusively. In other words, the spacecraft and equipment surrounding the astronauts had always, in simulations on earth, been the stimuli associated with intensive work behavior patterns and evaluation by superiors. The astronauts were not conditioned to relax in this environment.

Obedient, cooperative, conscientious, hard-working, and highly controlled behaviors have been encouraged by factors such as the strict, hierarchical chain of command and work ethic mentioned earlier. There have been limited opportunities for innovation or free-wheeling experimentation. The underlying concept of military professionalism demands that astronauts consistently behave in a manner perceived as self-assured, realistic, and emotionally stable.

PERSONALITIES IN SPACE

The most important function of psychiatrists and psychologists in the space program to date has been to screen out psychopathology in candidates (Helmreich et al., 1980). The potential astronauts for the Mercury project were extensively screened to meet seven criteria: (1) intelligence; (2) drive and creativity; (3) independence (plus tolerance for the dependence of others); (4) adaptability; (5) predictable responses to foreseeable and flexible responses to unforeseeables; (6) motivation for mission success (not personal success); and (7) low impulsivity (Jones and Annes, 1983). Some sources have suggested, however, that the early astronauts were highly competitive within their group. (According to Walter Cunningham, "There existed that one universal thread: competition...if we had to take a urine test, we competed to see who could fill the biggest bottle." Cited by Helmreich et al., 1980.)

Evaluation was less extensive for Gemini and Apollo. Applicants were expected to show a high level of motivation, a positive self-concept, emotional stability, and a satisfactory mode of relating to other people (Jones and Annes, 1983; Santy, 1983). An indication that someone had unresolved emotional conflicts might disqualify him (Jones and Annes, 1983). Identical to the Mercury pilots, candidates were expected to be "mission-oriented" instead of oriented toward personal achievement (Santy, 1983).

Since Apollo, prospective astronauts have been interviewed by two psychiatrists for two hours each session. The purpose of these screenings was to eliminate individuals who are or have been subject to psychosis, psychoneurosis, personality disorders, substance abuse, fear of flying, amnesia, neurotics or any other psychogenic symptoms (Jones and Annes, 1983). Generally, selectees were considered to be bright, well-integrated, and independent, with a good balance between conventionality, sensitivity, and creativity (Hartman and McNee, 1977, as cited in Jones and Annes, 1983).

Until the inception of the Space Shuttle program, astronauts were male, usually married, and the majority of them had a career military pilot background (Santy, 1983). All of the Mercury pilots were actual test pilots (Helmreich et al., 1980). The flight-trained astronaut with a military background not only predominated on flights into the late 1970's, he is definitely the spacecraft commander of current and future missions.

Previous astronauts have been described as having the "right stuff" (Wolfe, 1979). This typifies a person who can stand on his own feet, is always looking for new experiences, is willing to take risks and make his own decisions because he believes in himself. A current NASA flight surgeon and psychiatrist has labeled this type as an "explorer," someone who needs high levels of stimulation and functions well in a dangerous environment (Smith, 1986). Most of the personality data available deal with the military pilot, the population from which astronauts have traditionally been drawn.

The predominant characteristic of the military pilot seems to be that he is highly achievement-motivated (Foushee, 1982; Fry and Reinhardt, 1969, as cited in Alkov and Borowsky, 1980; Ursano, 1980). He also seems to have a high need for external change (Fry and Reinhardt, 1969, as cited in Alkov and Borowsky; Haakonson, 1980; Ursano, 1980). This pilot personality type aims to demonstrate both strength and competency and thrives on adventure and mastering difficult, complex tasks (Alkov and Borowsky, 1980). According to a NASA publication, the most successful aviators are those who experience positive emotions from the process of overcoming difficulties (Huss and Heusner, 1979).

According to studies conducted by Ursano (1980), the military pilot tends to be alloplastic; he is more concerned with concretely changing the environment than in changing himself. He is self-sufficient, direct, courageous, bright (not intellectual), well-controlled, needs routine, prefers short-range to long range goals, and seeks responsibility and novelty. He is also, however, impatient with personal imperfections, avoids and denies his internal emotional life, is cautious in interpersonal relationships, attributes inner feelings to external changes in the environment, and avoids introspection. The overall picture is a person with an active, achievement-oriented life who can be predicted to ignore his own emotions.

Similarly, Navy jet pilots score highly on personality scales designed to measure the factors of achievement, dominance, aggression, exhibition, consistency, and score below the norm in deference, abasement, affiliation, succorance, and nurturance (Fry and Reinhardt, 1969, as cited in Alkov and Borowsky, 1980). (Recent research by Jones, 1983, suggests the female pilot is very similar to the male pilot population.)

An astronaut candidate with a military flying background is assumed to have been adequately screened by the inherent life stresses, sudden life-and-death situations, and other career experiences (see Jones, 1986, regarding functional/dysfunctional flying attitudes). Therefore, no psychological testing is done. Originally evaluations attempted to ensure the best qualified candidates were chosen, but now the system is intended to simply determine that each selectee is fully qualified (Jones and Annes, 1983).

Any discussion conducted regarding the personality characteristics of the other three crew member categories is still quite speculative. We do not yet know if the current and future group of scientists and mission and payload specialists are homogeneous enough to make generalizations.

PERSON-ENVIRONMENT INTERACTIONS

Since the U.S. has not made a formal attempt to set up onboard psychological experiments, to record interactions with specific environmental features, or to use behavioral scientists in its ongoing training program (Bluth, 1981), there exist no systematic data on the specific interaction between personality and environment in the space program so far. We are limited to examining observed, often anecdotal, responses to spaceflight and to making assumptions and predictions given these observations.

I. OBSERVED REACTIONS

According to documented observations, astronauts have reacted to the spaceflight environment with space sickness, hyperarousal, fatigue, time compression, and loneliness. Space sickness, the space adaptation syndrome of negative bodily reactions to the space environment, afflicts approximately half of all astronauts (Connors, Harrison, and Akins, 1986). Some researchers suggest that this sickness, which compromises crew effectiveness, may have a significant psychological component (Christiensen and Talbot, 1986).

Overstimulation or "hyperarousal" has also been experienced by many astronauts (Aitken, 1970; Berry, 1972; Santy, 1983). Intense work schedules, excitement, diverse tasks, and the absence of temporal cues may contribute to this condition (Santy, 1983). The continual presence of other astronauts or the constant monitoring by mission control may be triggering high levels of evaluation apprehension. The presence of environmental cues that triggered intensive work behaviors during training sessions on earth may also contribute to sustained arousal. Physical symptoms include insomnia and eating abnormalities such as anorexia (Santy, 1983) and unexplained inefficiency of muscular coordination (Aitken, 1970). Continued hyperarousal would presumably cause even greater physical problems and performance deficits (Santy, 1983).

Fatigue seems a likely consequence of continued hyperarousal. Cosmonaut Valeryi Ryumin, who spent over a year in space on two flights, stated that after three to four months exhaustion sets in (Oberg and Oberg, 1986). Cosmonaut Vladimir Kovalonok reported that a cosmonaut is in a state of "constant alertness" (Bluth, 1984). A former astronaut agreed that in space one is "never off duty" (Douglas, 1984, as cited in Connors et al., 1986).

Some astronauts have experienced a perceptual-cognitive malfunction called "time compression." This altered time sense may be due to excessive mental workload, information overload, and cognitive processing from an inadequate data base (Christiensen and Talbot, 1986). Anecdotal accounts of perceptual, cognitive, and emotional aberrations among spacecrew members are also of concern to behavioral scientists (Christiensen and Talbot, 1986).

Loneliness and a longing for home have been observed (Connors et al., 1986). The amount of time spent communicating with family members has been known to increase as mission length increased (Gazenko, Myasnikov, Ioseliani, Kozerenko, and Uskov, 1979, as cited in Connors et al., 1986). Crew members of Skylab positioned themselves by the window so that they lined up with the horizon of earth (Cooper, 1976). Time spent looking through the window at earth may be a way for astronauts to symbolically keep in contact with home (Oberg and Oberg, 1986; Connor et al., 1986).

II. ASSUMED REACTIONS

The longest period in space spent by an American is the 84-day mission of Skylab III. The crew's environment was highly artificial, strange, potentially life-threatening, and required considerable effort to accomplish the supposedly simplest of tasks. They were given a heavy workload in an organizational climate that stressed achievement. The small group was highly homogeneous and operated under a military, hierarchical command structure. Given that these individuals have been described as thriving on adventure and challenges, very achievement motivated, had been in dangerous flying situations previously and had extensive experience with similar individuals in hierarchical organizations, the stress they experienced from these factors should have been positively interpreted.

Everything they did was closely monitored. They were told what to do and when to do it. They had limited competence on some of the experiments they were expected to perform daily. They had trouble finding the items needed for these experiments. They were made to feel that they were always behind the work schedule (and that their performance was therefore not up to standards.) They had no privacy, since all actions and conversations were recorded, leftover food and bodily wastes were weighed, monitors were attached to them during sleep, and so on. They were isolated from their typical support system, such as their family and friends. Interpersonal communications among the three were distorted by puffed faces and apparently faint voices.

These individuals habitually had and demanded a high degree of control over their surroundings, particularly in a work environment. Anything they did, they expected to do well. They were reprimanded publicly for a minor infraction of the rules, a direct attack on their self-esteem and ability to make their own decisions. Given the personalities and general experiences of the crew, these environmental factors were probably not experienced positively. The so-called revolt that occurred at the mid-point of the Skylab mission, when the three men called a temporary work halt (Cooper, 1976; Carr, 1985), could have been a means of increasing control and autonomy and also could have been a response of extreme frustration.

The element of controllability has apparently been very important to astronauts since the earliest days of the space program (Stoyva and Anderson, 1982.) Several leading test pilots declined to participate in the Mercury program because the pilot's role was so minor. The original "capsule" was windowless and these pilots objected to being "spam in a can." Only after the astronauts insisted, were manual controls and a window added to the re-christened "spacecraft" (Wolfe, 1979).

III. PREDICTED REACTIONS

The personality profile of military pilots suggests some additional conclusions concerning reactions. The typical military pilot is assumed to have inadequate strategies for coping with stressful emotional events (Ursano, 1980). He denies his emotions, seeks concrete solutions, and acts out of frustration when a specific objective is not achieved (Novello and Youssef, 1974). The crew of Skylab III was very blunt and humorless in its habitability criticism of the spacecraft (Cooper, 1976). Was this harshness just the required response to an ongoing habitability experiment or, instead, a reaction to negative experiences?

The pilot's extreme self-sufficiency and impatience with personal imperfections may well cause friction with other crew members, particularly those with different roles and backgrounds. Most importantly, however, he is used to a high degree of control over his environment, and that may be possible only in very limited ways within the confines of a space vehicle. Ursano (1980) states that "one can expect the pilot to have difficulties when he is confronted with failure at one of his goals, or with an ambiguous situation, particularly in a social setting" (p. 1246).

The pilot may use humor as a coping mechanism, but will not become tearful or withdraw or fight physically. He tends to look for a constructive, active solution and to speak out when faced with a difficult situation (Ursano, 1980). For example, the astronauts of Skylab II were renowned for providing an amusing narrative to ground personnel during onboard incidents that might easily have been interpreted as frustrating, such as vacuuming floating hair particles during a haircut (Cooper, 1976). Cosmonauts have also used humor to battle fatigue and emotional tension (Fefeelev, 1976).

Some studies have suggested that fliers (and astronauts) may be highly resistant to stress. Aviators have functioned effectively at a high level of life stress that would have precipitated illness in the non-aviator population (Alkov, 1975, as cited in Haakonson, 1980). If astronauts have confident task involvement and a sense of control in a laboratory setting, they can control their response to stress (when arousal measured by levels of epinephrine and cortisol is the stress indicator; Frankenhaeuser, 1980).

THE SOVIET SPACE EXPERIENCE

In the area of training for space exploration, the Russian approach appears to differ markedly from the American approach. In contrast to our emphasis on the mastery of tasks specifically related to flight requirements, the Russians place great importance on both psychological adjustment and the coping skills specific to the space environment (Connors et al., 1986; Petrov, Lomov, and Samsonov, 1979, as cited by Helmreich, 1983), an approach which superficially resembles the interactional analysis of person and behavior. The Group for Psychological Support is a very prestigious component of the Soviet ground team (Connors et al., 1986); the head of Soviet Space Medicine, Oleg Gazenko, represented the beliefs of his organization when he concluded that the limitations of living in space are not medical but psychological (Oberberg and Oberberg, 1986). Gazenko supported this conclusion when he stated that the 211-day mission of Salyut-7 flown in 1982 triggered no new biological changes in the human organism (Christiensen and Talbot, 1986).

The Soviets have been reported to use several techniques in cosmonaut training. They try to cognitively prepare their cosmonauts for every conceivable situation. Their program is considered more "rigorous" than American training, and several of the earlier cosmonauts presumably died from the combined mental and physical stress of preflight training (Canby, 1986). The purported goal of the Soviet space training program is to reduce the difference between the information cosmonauts have and the information they need to solve specific problems in space (Santy, 1983).

Devices as parachute jumping and survival training are used to develop personality characteristics such as self-reliance, self-control, self-confidence, and the ability to keep calm and alert in an emergency (Bluth, 1984). Crews are trained in human relation skills by role playing in simulated conflict and stressful situations (Zaitsev, 1982, as cited by Wood and Dunivin, 1985). According to Bluth (1984), crew members are also trained to withstand interpersonal pressures. For motivational purposes, the importance of different job tasks to mission success is heavily emphasized during training.

Cosmonauts in space are monitored using voice analysis to enable detection of excessive stress (Bluth, 1984). If the ground support personnel sense an increase in the stress level of the cosmonauts, they try different techniques to alleviate the sensation of being overwhelmed. For example, they may change the schedule, add pleasant distractions, arrange for family communication, and so on. There appear to be few if any negative repercussions due to psychological or social difficulties encountered in space for the cosmonauts (Connors et al., 1986).

According to published reports, no inflight psychophysiological impairments other than transient space sickness have affected the cosmonauts. Any behavioral problems have supposedly been rare and nondisruptive (Christiensen and Talbot, 1986). However, it is known that the Salyut 7 mission commanded by Vladimir Vasyutin was aborted because of his tense, nervous, abnormal behavior. He was reported to be suffering from a severe inflammation, perhaps pneumonia (Canby, 1986). Other sources have suggested, however, that his problems may have been psychologically based (Santy, 1983).

It has been admitted by the Soviets that, at roughly the 30-day point into a long mission, crew members typically begin to show hostility. This aggression has been successfully controlled onboard the spacecraft, but has often been directed at the support staff on earth (Bluth, 1984). According to the cosmonaut Sevast'yanov, disagreements are inevitable, but do not lead to physical violence because of microgravity (Bluth, 1985). Soviet experience indicates that the quality of work performance may decrease markedly after in-space stays of more than four or five months (Canby, 1986). The cosmonaut named Ryumin agreed; in his opinion, exhaustion sets in after three to four months in orbit (Bluth, 1985).

Psychology is considered important enough by the Soviets to play a central operational role in space, but it is not possible for us to determine the quality of their application of psychological concepts and techniques (Helmreich, 1983). Unfortunately, we also have no personality data on the cosmonauts. We do not know, for example, whether they are typically outgoing, group-dependent, assertive, controlled, or creative.

INTERACTIONS IN OTHER ISOLATED ENVIRONMENTS

The environment in a spacecraft is highly unique. There are other environments, however, which do share some of the same characteristics, such as physical and social isolation, confinement, and potential danger. A recent review of over 60 American and Russian scenarios approximating spaceflight, such as submarine cruises, spaceflight simulations, and winters in Antarctica was conducted by Kanas (1985). The available data are behavioral. The types or categories or personality profiles of the individuals placed in these isolated environments have not been reported and may not have been recorded.

Behaviors reported included: anxiety, anger, boredom, depression, restlessness, sleep disturbances, bodily complaints, time and space distortion, and problems in task performance over time (Palinkas, 1986; Santy, 1983). Individuals experienced mental inertia; they found it hard to concentrate, had memory problems, and experienced a general slowing of intellectual activities (Bennett, 1983). The social tension that existed between inhabitants sometimes triggered highly aggressive teasing, which was called "pinging" (Kanas, 1985). Members of isolated groups were usually not able to express interpersonal hostility openly (Smith, 1986), which may have contributed to withdrawal (Connors et al., 1986; Kanas, 1985; Shoemaker, 1986).

One outlet for hostility and frustration is communication with support personnel or other individuals located away from the confined environment (Connors et al., 1986; Jones and Annes, 1983; Kanas, 1985). Findings from space-cabin simulator studies have shown that repressed antagonism between crewmates is also expressed using excessively formal and work-centered speech patterns or by punishing inanimate objects (Jones and Annes, 1983).

The tendency for psychosocial problems to occur in these "analog" environments was found to be directly linked to mission length (Kanas, 1985). This conclusion seems obvious. In ordinary circumstances there exists a strong relationship between the intensity of a tension-producing environment and its duration, since less intense situations (or those an individual adequately copes with) can still produce negative effects when endured for long periods (Semmer, 1982). Extremely demanding environments endured for long periods would deplete a person's resources and therefore his ability to cope even more severely.

STRESS AS A PROCESS

The concept of stress was defined earlier in this chapter as the product of a person's appraisal of a situation and his ability to respond to its demands. The psychological appraisal model of stress (Lazarus and Folkman, 1987) states that the potentially stressful event is perceived during the primary appraisal as either beneficial, neutral, or positive. Secondary appraisal is the assessment of one's ability to sufficiently cope with the event. The interaction of these two appraisals determines the physiological, cognitive, emotional, and behavioral responses of the individual. Selye (1974), one of the best known researchers on stress, describes this process as a sequence of three stages which he termed the General Adaptation Syndrome (GAS).

I. THE STAGES OF STRESS

Before environmental demands are perceived, the body of the person is assumed to be in a baseline state physiologically. When the person does encounter the demanding situation, he enters the first stage, the alarm reaction. This initial shock phase of lowered resistance is followed by countershock which triggers the person's defense mechanisms. The second stage, that of resistance, is the period during which the defense mechanisms are operating at full tilt in their attempt for a return to equilibrium for the person. Following lengthy exposure to the same demanding environmental characteristics (to which the body has become adapted), the adaptation energy is finally depleted. The person is in the stage of exhaustion, when the adaptation mechanisms collapse (Selye, 1974). If the demanding situation is not alleviated in some way, the end result of this phase is the death of the organism.

On the other hand, it can also be asserted that "complete freedom from stress is death." That statement is central to Selye's conception of stress. Since an individual is always in some sort of environment, he is always experiencing demands. His perception of those demands ranges from highly pleasurable to extremely unpleasant with a low physiological reaction point of indifference in the center of the continuum. The arousal level is never zero, since that would be death.

II. STRESS STAGES IN ISOLATED ENVIRONMENTS

Rohrer (1961, as cited in Kanas, 1985) and subsequent researchers have discovered that isolation in locations such as the Antarctic and in submarines seems to provoke three sequential reactions. These real-life observations seem to parallel quite closely Selye's three GAS stages of alarm, resistance, and exhaustion.

According to Rohrer's observations, individuals first experienced heightened anxiety. The degree of danger perceived by the individual determined the degree of this response. Rohrer believed that this stage would trigger whatever psychotic episodes were going to happen. The second reaction was one of depression. The men settled down and resigned themselves to perform routine duties and emotional expression of any kind decreased steadily. This stage was the longest period. At the very end of the mission, the isolatees suddenly became highly emotional and even aggressive, almost as though their emotional controls had "burned out." During this stage, which is labelled anticipation, hostility was likely to be expressed, work performance deteriorated markedly, and individuals reverted to "adolescent" behavior.

Selye's conceptualization of GAS could also explain the recommendation, due to military experience, that indeterminate mission length is inadvisable (Helmreich et al., 1980). For example, the indefinite rotation used during World War II was changed to a fixed, one-year combat tour in Vietnam. Possibly, individuals have to ration their adaptive resources so that they are not exhausted before the end of their mission. They may feel less control over the situation with combat tours of an unknown length.

Time passage in isolated and confined situations seems to be closely watched (almost as if one were in prison). The half-way point of a mission seems to have particular emphasis for isolatees. For example, members of the Naval Support Force in Antarctica would typically experience a severe mid-winter depression at the two-month point (Shoemaker, 1986), and the much-referenced disagreement during Skylab III occurred 40 days into the 84-day mission (Carr, 1986). One senior Naval submarine commander typically scheduled a party precisely at the mission halfway point to emphasize that the mission was half completed and to counteract increasing depression (Sullivan, 1986).

Why do crew members become depressed? Interpersonal hostility is often unexpressed and may be turned inward during social withdrawal. Crew members may consciously suppress their resentments for the good of the mission itself (Jones and Annes, 1983) and because survival depends on a coordinated team effort (Smith, 1986). A recent review of Navy personnel who had wintered over in Antarctica found that those who were self-sufficient and had positions allowing them some autonomy coped better and had fewer medical and psychological problems than members who did not possess these characteristics (Palinkas, 1986). Other factors highly correlated with good mental and physical health (both "on the ice" and elsewhere) were a high need for achievement and a strong sense of control over events (Palinkas, 1986).

Unfortunately, most of these observations cannot readily be tied to personality data. (One anonymous observer, however, noted that by the end of the mission, the strivers and the complainers had "burned out", and it was the unimaginative plodders who kept getting the job done and carrying the rest of the crew. A psychiatrist responsible for selecting people to winter over in Antarctica also observed that duller, less imaginative people adjusted better to those conditions; Blair, 1986.) Presumably, whether or not the individual had free choice concerning the isolation (volunteers versus draftees) should be a major moderating variable on the amount of negative stress experienced. These individuals were not as select as our former and current astronauts, but as a group they may have characteristics in common with future spacecrews.

III. STRESS-RESISTANT PERSONALITIES

Who copes best with stress? Researchers interesting in formulating the answer to this question are faced with two major problems. First, it is unethical to induce high levels of stress in humans in a laboratory situation (Cameron and Meichenbaum, 1982). The second problem is a methodological one. Coping can be defined physiologically (and even behaviorally) for measurement in an immediate, short term scenario. Given the cumulative effects of situational demands and the resulting likelihood of exhaustion at different points for different individuals, long term effects are even more critical in predicting stress levels, yet quantifying this type of coping is difficult. One compromise used by researchers is to study those individuals who have continued to function without breakdowns under conditions of extreme negative life stress (one example would be the pilots studied by Haakonson, 1980). Although possibly instructive, such findings may be limited in generalizability.

The person who uses effective strategies in coping can be described both in terms of his personality and in terms of the coping resources that he has available (e.g., Lazarus and Launier, 1978, as cited in Cameron and Meichenbaum, 1982), an approach quite appropriate to an interactional analysis.

Stress research has identified several personality characteristics common to stress resistant individuals. This hardiness profile is typified by a strong commitment to oneself, a sense of meaningfulness in one's life, and a vigorous attitude toward the environment (Kobasa, 1979). This type of person has also been succinctly described as having challenge, commitment, and control (Kobasa, Hilker, and Maddi, 1979) and as having "resistant resources", described as a sense of social belongingness, coherence, and manageability of life (Antonovsky, 1979). This person believes in his own effectiveness and ability (Kobasa and Pucetti, 1983).

The military flier or prototypical astronaut was described in an earlier section using several personality terms that imply satisfactory coping with respect to demanding environments. He can be assumed to have a strong sense of commitment, an attitude of "vigorousness" toward the environment, an expectation of control over outcomes, and confidence in his abilities.

Resistance to stress in the combat environment has also been studied. Data collected on military fliers during WWII have subsequently been analyzed and showed that a positive sense of control, competence, and group membership were major factors in predicting courageous responses to difficult situations (Rachman, 1978, as cited in Stoyva and Anderson, 1982).

A person facing a demanding situation is not necessarily alone. He has a social support system, a social network that is his primary resource for general worries and unhappiness (Furin, Veroff, and Feld, 1960, as cited in Lieberman, 1982). For example, if he perceives that he has the support of his boss, this fact can counteract somewhat the negative effects of stress (Kobasa and Pucetti, 1983). The sources of social support might be one's spouse, parents, in-laws, children, other relatives, friends, co-workers, work subordinates/superiors, neighbors, and so on. There are three general categories of social support: emotional, cognitive, or physical (Lieberman, 1982). Emotional support includes such things as intimacy, listening, approving, reassuring, and empathizing. Cognitive support involves pointing out new ways to look at circumstances, giving factual information, and giving advice or guidance. Physical support is simply doing something active to help someone. (It must be added, however, that family and friends can at times be demanding and therefore possibly detrimental; Pearlin, 1982.)

Personality factors obviously influence one's willingness to utilize his/her social support system. For example, only half of the recent widows studied by Bankoff (1981, as cited in Lieberman, 1982) who believed they had people they could count on for emotional support actually reported turning to them. Those who rarely ask others for help tend to fall into two categories. One group is very self-reliant, seldom perceives demands as negative, and has a strong but select support network with which they discuss almost all ongoing situations. The others are "reluctant nonseekers", since they seldom turn to people for help because they perceive those people as unsupportive and unreliable (Lieberman, 1982).

Although no studies have as yet compared the stress-resistance of these two categories, certain conclusions seem probable. "Reluctant non-seekers" would be a poor choice for spaceflight, since these individuals are unlikely to use support systems to buffer stress and would be predisposed to withdraw when faced with extreme demands. Self-reliant individuals capable of trusting select others should cope well with demanding situations if occasional confidential access to support system members (such as spouses) is allowed and if one or more fellow crew members is perceived as highly trustworthy. Preflight training could encourage mutual professional and personal cooperation (as opposed to competition) to generally increase trust levels among the crew. Specific research regarding the process of coping effectively with demanding environments is detailed in the following section.

IV. COPING WITH STRESS

Stress as a process of appraisal and performance can be modified by several factors. One moderating variable that has recently received attention from researchers is information. The more information a person has about the specific demands of a situation, how other people have successfully and unsuccessfully responded to those demands, and the consequences of responding inadequately, the less negative stress is experienced. (This seems to be an assumption underlying the Soviet approach to cosmonaut training.) Presumably, information is useful because it gives the person more control over that situation and he then stands a better chance of experiencing a positive outcome (Baum, Fisher, and Solomon, 1981). Even if the information only explains methods of coping with stressful situations in general, perception changes and adaptation is improved (Baum et al., 1981).

Experience may be a major reason why NASA prefers pilots who have supposedly handled previous life-and-death situations to command spacecraft (Jones and Annes, 1983). By surviving near-miss situations, pilots may have developed an internal mechanism, such as suppressing or denying fear signals, to cope with physical danger. This established response may, however, be inadequate for handling different types of demands, such as interpersonal conflicts. Persons who lack skills for coping with a category of potential stressors are described as having a repertoire deficit (Cameron and Meichenbaum, 1982). Mission planners concerned with lessening maladaptive inflight behavior may need to consider which categories of potential stressors are most relevant to a spaceflight environment and then establish whether crew members have (or need training regarding) adequate coping repertoires.

Stress researchers have identified two primary coping styles. The ability to effectively modulate emotional responses to stimuli is called "fear control" or "emotional coping," and the ability to use instrumental, active, problem-solving behavior to change or remove the stressing agent is called "danger control" or "problem-focused coping" (Anderson, 1976; Wilson, 1981, 1982; Folkman and Lazarus, 1980, as cited in Kobasa and Pucetti, 1983). The effectiveness of social support in buffering negative stress may occur because it contributes to the "emotional coping response" (Kobasa and Pucetti, 1983).

With an underlying distinction similar to emotional versus problem-focused coping, the Miller Behavioral Style Scale was developed to measure how different individuals react to danger signals (Miller, 1979; Miller and Grant, 1980). The approach of coping by thoughts and actions that enable someone to psychologically escape from the situation is called "blunting." (It is possible that the social withdrawal noted in isolated, long-term environments is an example of reality denial or "blunting".) The opposite approach of coping by seeking information, looking for predictability, and being vigilant in facing threat is called "monitoring." Monitoring is an effective approach to a concrete, unambiguous problem, since many researchers assume successful coping is based on interpretations that minimize distortions and blind spots (Cameron and Meichenbaum, 1982). In the face of persistent threat, however, the person using this coping response may become susceptible to the GAS exhaustion stage (Selye, 1974).

Given the personality description of the typical military flier, an astronaut from this background probably copes with dangerous or demanding circumstances of any type using the monitoring/problem-focused coping approach. This astronaut would be more susceptible to hyperarousal and exhaustion if he rarely "blunts" or takes mental time off from the immediate situation. When emotional comprehension and/or an emotional response is required, he would be at a disadvantage, a conclusion suggested by Ursano (1980) and reinforced by the apparent ambiguity of interpersonal exchanges.

Although the preceding paragraph suggests several possible relationships between personality characteristics and environments, an effective interactional analysis requires a more systematic and thorough look at personalities and situations. The next major section in this chapter therefore discusses six well-researched personality dimensions.

PERSONALITY TRAITS

A personality trait is a relatively stable, enduring behavioral disposition that an individual exhibits over time (Epstein, 1977). It is distinct from a state, which refers to a transitory condition, such as varying emotions or moods. For example, a person can be in a state of fear in a specific situation, but if his behavior is frequently fearful in different situations, then fearfulness is a trait. Cattell (1964, as cited by Feshbach and Weiner, 1982) theorized sixteen basic "source" traits and his resulting Personality Factors Test is widely used to measure the relative strengths of these traits in individual subjects. Eysenck (Eysenck and Eysenck, 1964, as cited by Eysenck, 1982) proposed the existence of three underlying personality dimensions: introversion/extroversion; emotional stability; and psychotism (impulsiveness).

Some researchers have complained that personality traits alone are not effective predictors of behavior (e.g., Mischel, 1968). Interactionists would agree, since they contend behavior is mutually determined by the person and the situation and their ongoing interaction (e.g., Bandura, 1986).

Personality psychology (in conjunction with situational considerations) can contribute to behavioral prediction when certain conditions are met. Individuals may be very consistent in displaying particular traits across multiple situations, yet inconsistent regarding other traits. Research has shown that individuals can accurately predict which personality traits they consistently show in diverse circumstances (e.g., Bem and Allen, 1979, as cited by Feshbach and Weiner, 1982). Individuals can assist psychologists, then, by identifying which traits are important or central in their overall personalities. Traits also have maximum impact on intentional behavior when the situation has been freely chosen, is ambiguously structured, the role most appropriate to that situation is unclear, and the "best" behaviors for that situation are also unclear (Mischel, 1977). Because the spaceflight environment frequently fits these criteria, major personality characteristics, perhaps as predicted by the astronauts themselves, may be very predictive of behavior. Existing personality research that lends itself well to an interactional analysis seems to have focused on six major traits or trait combinations. They are: locus of control, intrinsic motivation, extroversion/introversion, field dependence/independence, type A/type B behavior pattern, and sensation seeking.

I. LOCUS OF CONTROL

The single personality trait to which stress researchers have paid the most attention is the concept of locus of control (Kobasa and Pucetti, 1983). A person with an internal locus of control perceives that his actions impact his environment. A person with an external locus of control, on the other hand, does not believe that his actions have much if any effect and may be experiencing learned helplessness (Abramson, Seligman, and Teasdale, 1978). People who perceive themselves as self-directed act more consistently across different situations than do people who perceive themselves as adjusting their behavior to fit specific situations (Snyder, 1983).

II. INTRINSIC MOTIVATION

Intrinsic motivation, although it may sound similar, is distinct from the internal versus external locus of control concept. Individuals with intrinsic motivation have a high need for competence and self-determinism. They seek and try to conquer the challenges perceived as optimal for their capabilities. Intrinsic motivation is described as having three components - curiosity, preference for challenge, and independent mastery (Harter, 1978, as cited by Deci and Ryan, 1985). As a psychological term, intrinsic motivation seems to refer to the values or beliefs internal to an individual which motivate the behavior of that individual. (Extrinsic motivation is not a personality term used to denote lack of intrinsic motivation.)

III. EXTROVERSION-INTROVERSION

There is a substantial body of empirical evidence (summarized by Feshbach and Weiner, 1982) indicating that extroversion-introversion is a major personality dimension. The extrovert's energy is directed toward external objects and events; he is outgoing, impulsive, uninhibited, makes friends easily, is socially confident and participates often in group activities. The introvert emphasizes his inner experiences. Introverts are typically quiet, retiring, introspective, lower in social self esteem, value privacy and close friendships, expect interpersonal disagreements, and see themselves as too other-directed (Eysenck and Eysenck, 1964, as cited in Morris, 1979).

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VI. SENSATION-SEEKING

Each person seeks to maintain the optimal level of "arousal" in their central nervous system by choosing experiences or environments that are either stimulating or soothing. For most people, a moderate level of arousal is preferred. For individuals at either extreme, however, the preference is different. Some may be overwhelmed by small amounts of stimulation, while others may build an entire lifestyle around seeking high levels of stimulation. Several psychologists have been investigating the personality profile of these latter individuals, "sensation seekers" (Zuckerman, 1983; Farley, 1986).

Sensation seekers feel best and function most effectively when experiencing high levels of arousal (Zuckerman, 1969, as cited in Zuckerman, 1983). Stimuli which arouse sensation seekers typically are characterized by variety, novelty, complexity, unpredictability, uncertainty, flexibility, intensity, and conflict (Farley, 1986). Sensation seekers may have different information processing and reward mechanisms than those in the majority who find moderate arousal preferable (Zuckerman, 1983). Extroversion is also common among these individuals (Zuckerman, 1983; Farley, 1986).

The measurement of sensation seeking tendencies has centered around the Sensation Seeking Scales developed in 1964 (Zuckerman, Kolin, Price, and Zoob). Scores on the SSS predict, for example, how long novice scuba divers will stay down and how deep they will go, how much and at what odds individuals will place bets, and who belongs to volunteer firefighter groups (summarized in Zuckerman, 1983).

This trait has been broken down into four subscales: thrill and adventure seeking; experience seeking; disinhibition; and boredom susceptibility (Zuckerman, 1974, as cited in Zuckerman, 1983). The component of disinhibition is very similar to the trait of impulsivity (Barratt and Patton, 1983), although high sensation seekers do not necessarily lack impulse control (Zuckerman, 1983). Farley has suggested that sensation seekers are likely to polarize into either delinquents or heroes (Farley, 1986). Presumably, delinquents are the ones with low impulse control.

THE PROJECTED SPACE ENVIRONMENT

The environment experienced by space station or vehicle inhabitants has been described at some length in the first part of this chapter. Physically, astronauts will experience cramped quarters, weightlessness, hygiene difficulties, physical confinement, stimulus deprivation, and other circumstances very different from Earth. Any equipment malfunctions will be inescapable, unless crew members are capable of effecting repairs. Socially, astronauts may feel both crowded and isolated from their respective social support systems. Tasks may be constrained by mission goals or time or equipment limitations. However, responsibilities assigned to specific crew members will determine if tasks still have high visibility, performance pressure, and limited autonomy. When missions become prolonged, tasks may instead be characterized by repetition, underload, lack of visibility, and even boredom.

The demographics of the people onboard American spacecraft have already changed during this decade. Women have been Shuttle crewmembers, as have payload and mission specialists, scientists, schoolteachers, and even a Senator. In the case of the manned space station sponsored by the European Space Agency (ESA) and slated for the mid-1990s, the crews will be truly international. The base is to have three laboratories and cabins for eight people. One of its main functions will be as a staging post for manned and unmanned missions further out into the solar system (Marsh, 1987).

The command structure of future spacecraft will probably still be vertical and military. In the case of the manned space station planned for the mid-1990s, command status and organizational climate are debatable, since the countries involved are squabbling over whether or not the U.S. will control the station (Marsh, 1987). The question of how well scientific civilians or individuals from other nations will respond to the type of organizational climate and high control familiar to U.S. military members is simply unknown. Nevertheless, if we look at the most likely space environment characteristics, we can draw some tentative conclusions about individual reactions to these characteristics, as the following discussion demonstrates.

PROJECTED PERSON-ENVIRONMENT INTERACTIONS

When we look at the mutual interaction of the environment and the person, we have arrived at the heart of an interactional analysis. The first division in this section will examine how the personality traits of locus of control, intrinsic motivation, extroversion/introversion, field dependence/independence, type A behavior, and sensation-seeking interact with the environment. Because personality traits have rarely been considered in published space-relevant literature, this approach is speculative, yet extremely important. Therefore, the interaction between each major personality factor and several situational variables is also visually represented using graphs. If current research seems to indicate that an environmental factor will be perceived negatively, positively, or with indifference, a "data point" was placed on the graph. If no research exists, then the author made a logical attribution, and a question mark was placed at the probable interaction position. The illustrative interactional analysis being used is derived from Magnusson's approach (1982).

PERSONAL FACTORS

I. LOCUS OF CONTROL

Individuals who are characterized by an internal locus of control feel less crowded in a dense situation than those with an external locus of control. Presumably, internals feel enough in control to be tolerant of interference, while externals have a larger personal zone as a buffer to give them control over interpersonal contacts (summarized in Schmidt and Keating, 1979).

Generally, persons with an internal locus of control are more independent, better able to delay gratification, and cope better with various problems and situational demands than externals (Lefcourt, 1982). Can we assume that an astronaut is more likely to have an internal locus of control, i.e., that becoming an astronaut does not just "happen" but is actively worked and planned for? Probably. As spacecrew members, they then have the potential to cope very well with inflight demands over extended periods of time.

-----Insert Figure 1 About Here-----

Locus of control has been approached as a situational variable as well as a personality trait. Researchers have manipulated the amount of control perceived by subjects. Studies have shown the higher the level of perceived control, the fewer the negative emotions experienced by subjects in demanding environments (summarized by Kobasa and Puccetti, 1983). Allowing someone with an internal locus of control, the maximum amount of autonomy possible in a demanding situation should greatly reduce any negative stress experienced.

II. INTRINSIC MOTIVATION

Intrinsically motivated people need to be good at what they do. Their self-esteem may have developed from repeated success that was internally attributed. When a person engages in behavior relevant to his self-image, he is motivated to do well because his pride is at stake (Feshbach and Weiner, 1982). People whose main goal is high achievement have generally been found to be moderate, not extreme, risk takers. Only insecure individuals motivated by a need to avoid failure show extreme behavior that is either consistently risky or consistently safe (summarized by Siegelman, 1983).

A strong need for achievement has been shown to characterize military fliers (Ursano, 1980) and has historically been used as a selection factor in choosing astronauts (Santy, 1983). The assumption could be made that fliers selected to be astronauts are not particularly insecure or motivated by failure avoidance. Both populations would also seem to be characterized by the subcomponents of independent mastery, challenge preference, and curiosity. Does the drive for achievement suffer from negative feedback? In the short term, probably not. In the long term, possibly.

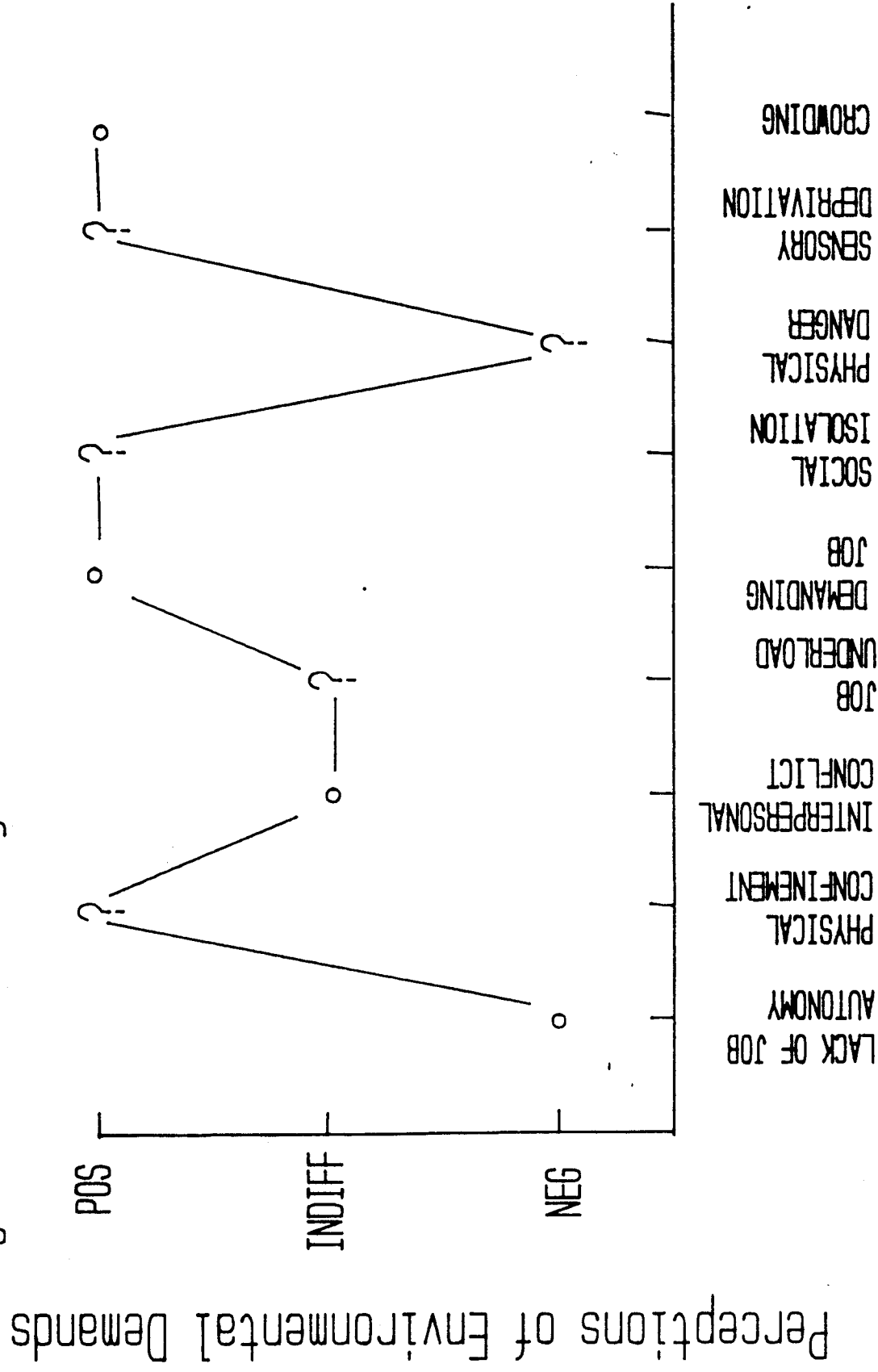
-----Insert Figure 2 About Here-----

Feedback on task accomplishment obviously affects immediate motivation. Positive feedback can give a person a higher level of intrinsic motivation as long as it is perceived as informational, not feedback designed to control or demonstrate power over the person (Deci and Ryan, 1985). The effect of reinforcement also depends on the attribution for success and self-involvement in the task (Feshbach and Weiner, 1982). Under conditions of high self-involvement and an internal attribution for success, positive informational feedback increases intrinsic motivation and self-esteem.

III. EXTROVERSION/INTROVERSION

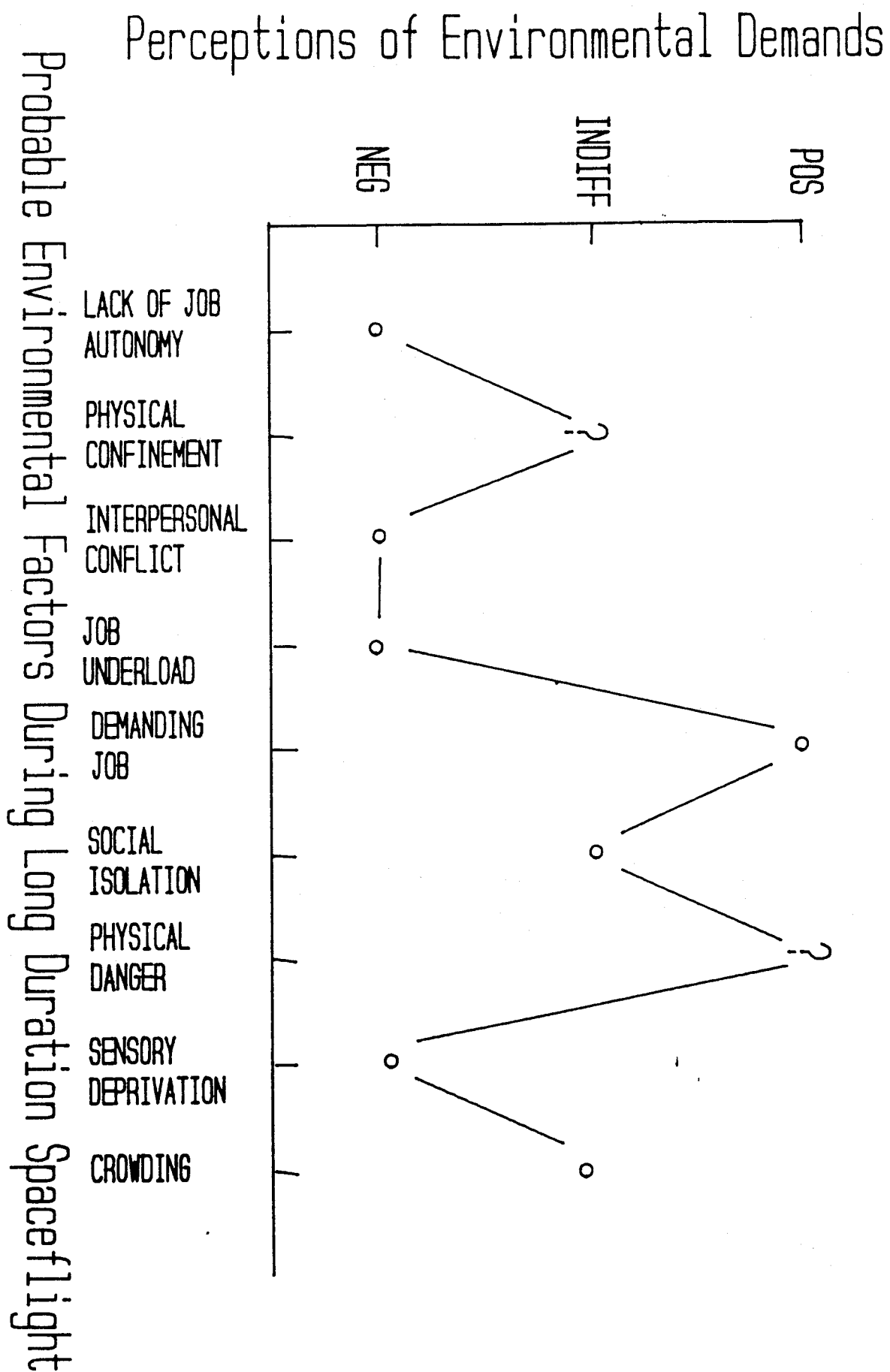
How do extroverts and introverts cope with demanding situations? They use very different coping strategies. Introverts tend to be sensitizers and extroverts to be repressors. Repressors actively deny or prefer not to express emotional experiences or adjustment problems. They can present themselves in socially desirable ways and tolerate great amounts of discomfort for short periods. Sensitizers are very aware of negative emotions and may use isolation or rationalization as a response. The distinction seems to be that introverts oversimplify external information and introverts oversimplify internal information, with resulting coping deficits for each. Researchers are not sure whether introverts have more anxiety and other emotional difficulties than extroverts, or whether they are just more willing to admit them (Morris, 1979).

Figure 1: Personality Trait of an Internal Locus of Control



Probable Environmental Factors During Long Duration Spaceflight

Figure 2: Personality Trait of Intrinsic Motivation



-----Insert Figure 3 About Here-----

Since repression of hostility is a common response in isolated and confined circumstances (e.g., Smith, 1986; Kanas, 1985), extroverts may be more likely to volunteer for those kinds of situations. Introverts may be too concerned about the anxiety implicit in isolation or danger to volunteer.

IV. FIELD DEPENDENCE/INDEPENDENCE

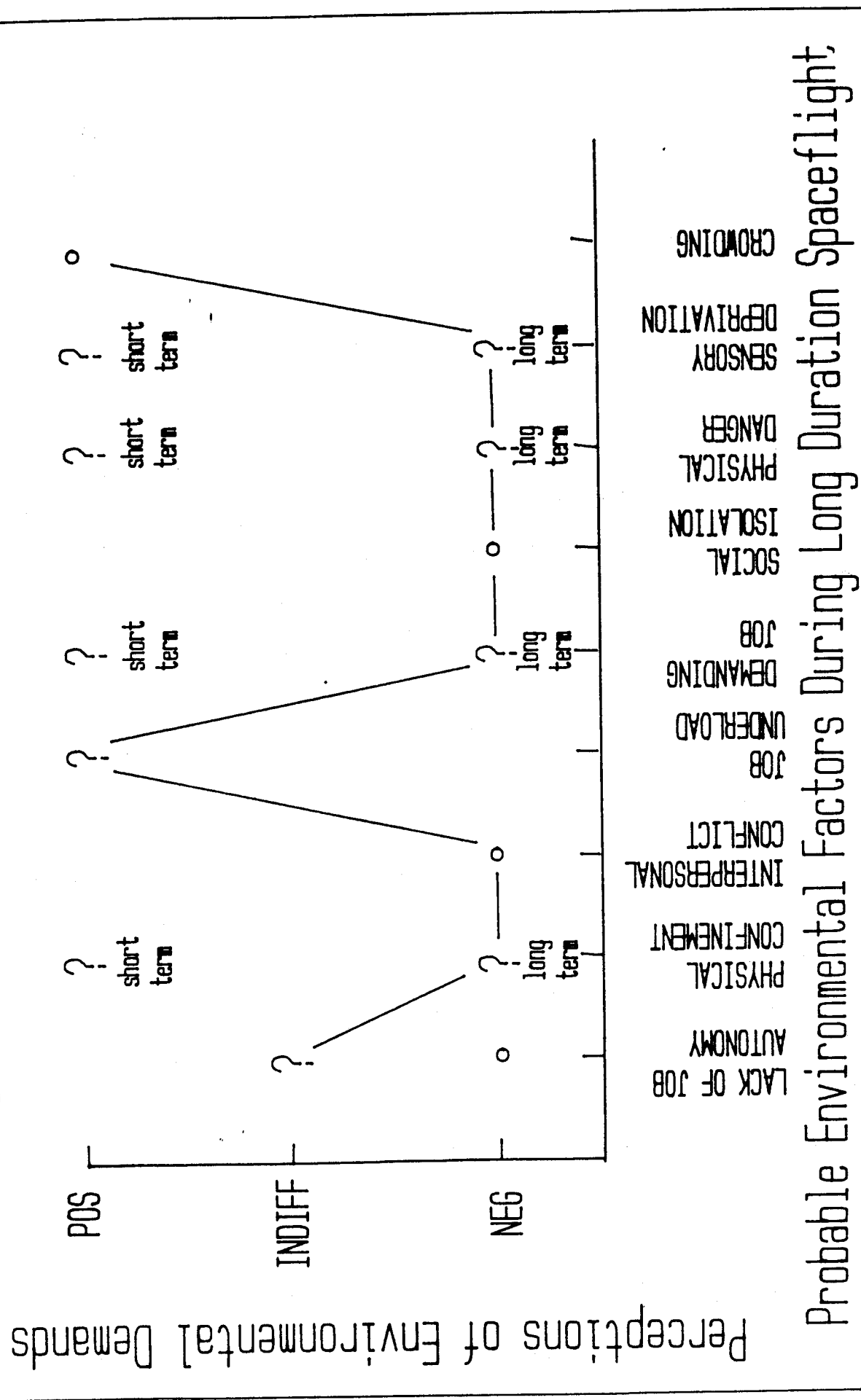
A person who is field dependent searches the immediate social environment for information on how to cope with ambiguity (Morris, 1979). His vigilance could be termed a "monitoring" approach to social coping (defined by Miller, 1979) and his awareness could minimize interpersonal conflicts in a space vehicle or station. The field independent person is probably more socially aloof and, because of his skill in cognitive analysis (Morris, 1979), would approach difficulties with an active, logical "problem-focused" coping style (defined by Miller, 1979). If he feels overwhelmed by the demands or conflicts of a social group, he might repress his reaction or rely on "blunting" to remove himself. Withdrawal is another way to escape interpersonal anxiety or hostility and has been frequently reported in isolation (Kanas, 1985).

In a zero gravity setting, would a field dependent person be more likely to prefer one surface be designated as the ground and another as the ceiling? Given the trait definition, this assumption seems logical. We might then conclude that we have been sending both field dependents and independents into space, since definite differences in orientation preference have been observed, particularly among the Skylab astronauts (Cooper, 1976). An inadequate amount of personality research has been conducted, however, to suggest several implications of field dependence/independence in the spaceflight environment. Since a few recent studies have suggested field dependence/independence is tapping most of the same qualities as the trait of locus of control (Morris, 1979), no presumed interactions were graphed for this concept. The main implication seems to be that field independents may experience more interpersonal difficulties during long duration space flight.

V. TYPE A

Numerous studies have looked at TABP individuals in very demanding circumstances. Researchers are interested because these competitive, over-achieving individuals are very prone to coronary disease. Their underlying hostility and irritability, if detected during selection, would theoretically disqualify them from spaceflight (Jones and Annes, 1983). However, an environment that is exceptionally demanding in areas important to someone's self-esteem could bring out this pattern of behavior in almost **anyone** (Roseman and Chesney, 1982). For instance, did the excessive amounts of work expected by mission control trigger TABP responding and hostility from the Skylab III crew? Has hyperarousal been a recurring problem in space because high expectations have encouraged TABP? If the US is in charge of the ESA space station mission, how will individuals from less time-driven societies react to our type A supervision? Will crew members interact with disappointment and resulting hostility if task expectations are not met according to stated time constraints? These questions have no answers yet.

Figure 3: Personality Trait of Extroversion



Control is critical to persons displaying TABP and, when they perceive diminished control, they react very negatively (Strube and Werner, 1985; Rhodewalt, 1984). Brief exposure to uncontrollable situations has produced exaggerated responding by Type As, termed "hyperresponsiveness", and prolonged exposure has produced depressed responding, termed "hyporesponsiveness" (Matthews, 1979, as cited by Matthews, 1982).

Because Type As strive for task control, they are often reluctant to delegate, even when other people have clearly superior task abilities (summarized by Strube and Werner, 1985). They value productivity, have high internal standards (which may be ambiguous), compare themselves to others, and self-blame when something goes wrong (Rhodewalt, 1984). If placed in a situation where a response that would establish control is not known, Type As are more likely to keep pushing until they discover that response, which implies they may exert more actual control than Type Bs in such real-life situations (Strube and Werner, 1985).

-----Insert Figure 4 About Here-----

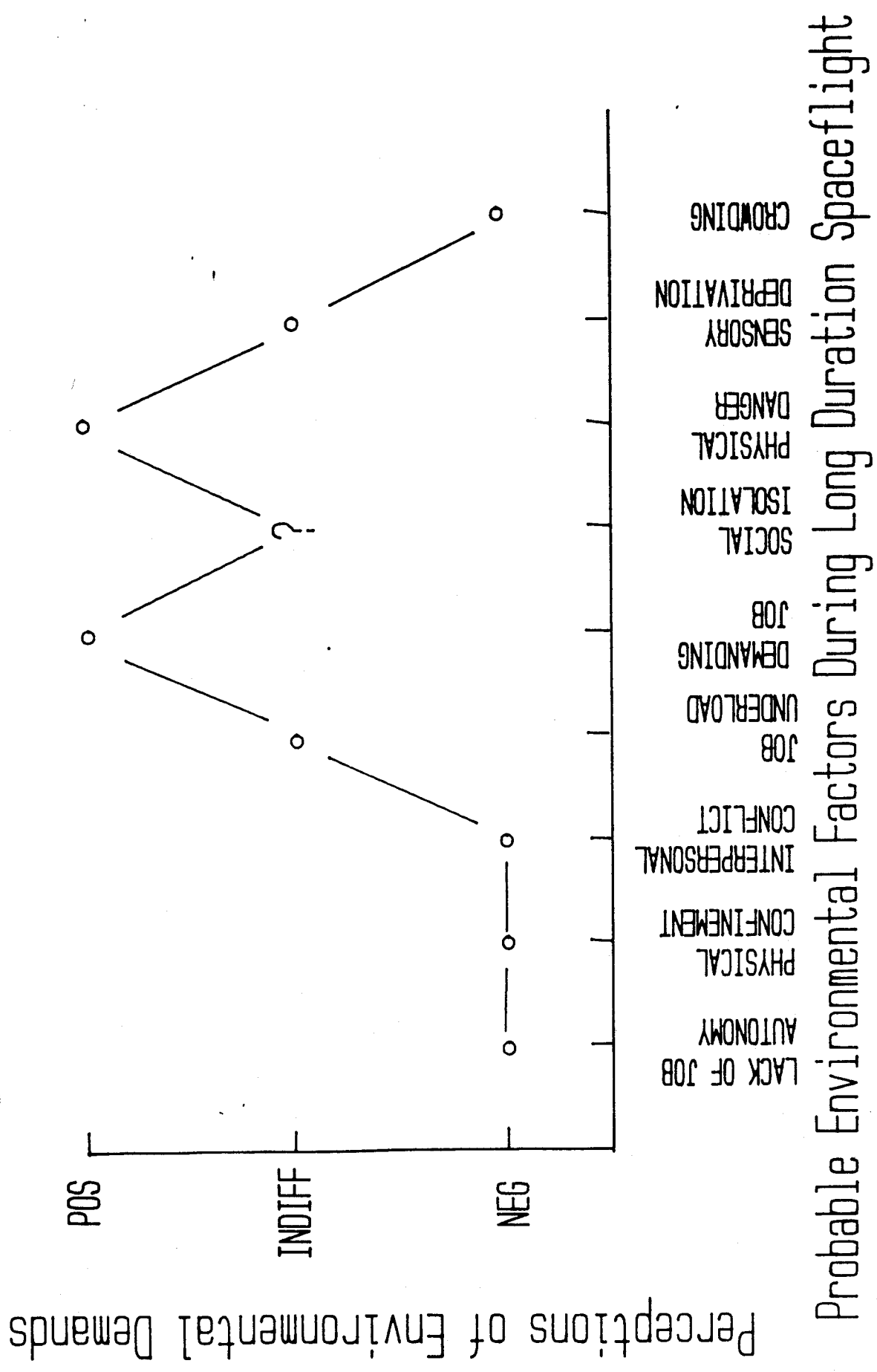
Individuals displaying TABP are also highly self-involved. This self-involvement may lead to feelings of isolation, incompleteness, hostility toward others, and an incapacity to give and receive social support (Scherwitz, 1974, as cited in Fischman, 1987). Since social support can be critical in mediating stress, unwillingness to seek or give support to fellow isolates would increase negative stress levels. If the spaceflight environment is making TABP more likely, then it would appear that personal and interpersonal difficulties may become more likely during a long duration mission.

VI. SENSATION-SEEKING

Astronauts with a flying background may be sensation-seekers. The earliest astronauts, in particular, fit into the "explorer" category (Smith, 1986). Their lifestyles and career aspirations could have evolved because of overriding needs for stimulation and challenge and recognition. Flying is adventuresome, thrilling, even unpredictable. Fliers function effectively (and even seem to thrive) at high levels of arousal; e.g., aerial dogfights, inflight emergencies, etc. They often appear unconventional and unpredictable (qualities which improve survival odds in combat) and may even be "show offs." Aviators are aggressive, courageous, self-sufficient, dominant, look for novelty, and need high levels of external change (e.g., Ursano, 1980).

Research has shown that high sensation seekers experience significantly less discomfort than low sensation seekers in handling negative life situations (Smith, Johnson, and Sarason, 1978), as do aviators (Haakonson, 1980). Presumably, they evaluate themselves as being capable of handling situational demands. If exposed to sensory deprivation or put in a monotonous confinement situation, sensation seekers will become restless and will try to stimulate themselves visually or by physical exertion (Zuckerman, Persky, Hopkins, Murtaugh, Basu, and Shilling, 1966, as cited in Zuckerman, 1983). This component of the sensation seeking trait has been labelled by Zuckerman (1983) as boredom susceptibility, as mentioned earlier. Awareness of this tendency may well be one reason why, when the Mercury astronauts were screened, they were expected to have "low impulsivity" so that they would react to demanding situations without physically acting out (Jones and Annes, 1983).

Figure 4: Personality Trait of a Typical TABP



How do sensation seekers react to risk? Predictably, they appraise situations as less risky than do those low in this trait (Zuckerman, 1979, as cited in Zuckerman, 1983). Even given an equal appraisal of risk, high sensation seekers anticipate more positive arousal from a situation, while lows anticipate more fear and anxiety (Zuckerman, 1976, as cited in Zuckerman, 1983). (NASA itself concluded the most successful aviators experience positive emotions from overcoming challenges; Huss and Heusner, 1979). Indeed, the risk in a given situation is a large part of its appeal to high sensation seekers (Farley, 1986). Bennet (1983) poses an interesting question, however, in his comprehensive summary of behavior in extraordinary situations: are individuals who deny the reality of risk **dangerous** to themselves and to others?

ENVIRONMENTAL FACTORS

The preceding section has examined person-environment interactions from the perspective of various personality traits. The second half of this section will focus on the impact of seven specific environmental factors on person-environment interactions in space. The factors to be discussed are personal space, crowding, social isolation, sensory deprivation, sensory overload, physical danger, gender differences, and organizational demands.

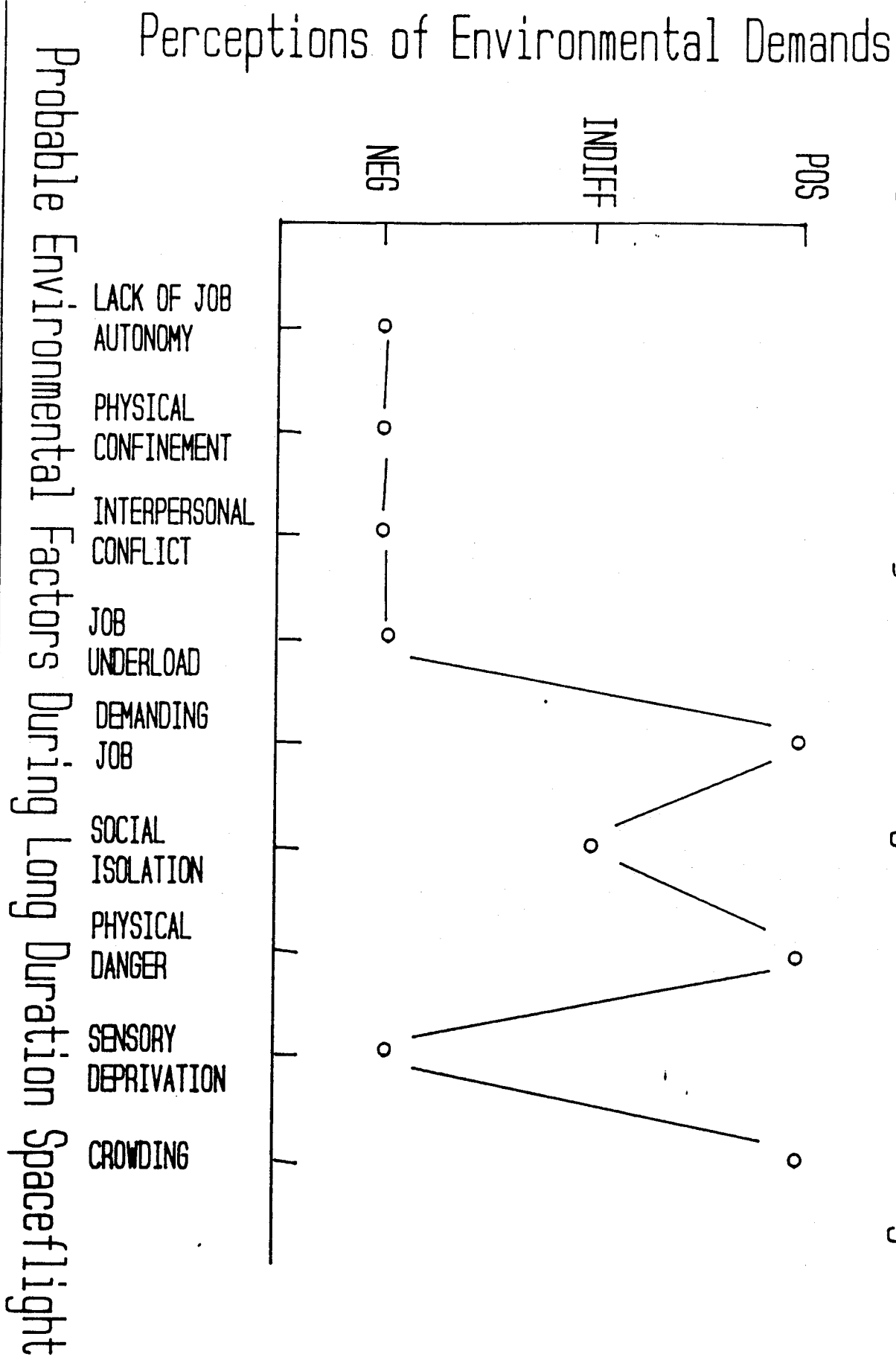
I. PERSONAL SPACE

The other people who surround a crew member during spaceflight will be mixed with regard to gender, nationality, and vocation. One area of concern may be preferred personal spaces. Different cultures define an appropriate personal zone differently, although it is usually considered an extension of **self** in most societies. Because of well-established behavioral norms, for example, large personal spaces are not relevant in Chinese culture (Schmidt and Keating, 1979). In another example, Latin Americans and North Americans have very different personal boundaries (Helmreich et al., 1980). Individuals with different vocations may also differ in how much interpersonal contact they expect on the job. Personal space expands when people are in a highly demanding situation (Dosey and Misels, 1969, as cited by Wood and Dunivin, 1985). Diverse perceptions about the appropriate distance between inhabitants of a space station, such as the base to be launched under the aegis of the ESA in the mid-1990s, may lead to confusion, arousal, and eventually animosity.

II. CROWDING

With several people in a small area, crew members may feel crowded. This label is applied when population density triggers the perceptions of control loss and goal blockage (Schmidt and Keating, 1979). This crowded feeling is more intense in a primary than a secondary environment (Stokols, 1976, as cited by Schmidt and Keating, 1979). A primary environment, such as work or home, is where a person spends a great deal of time, engages in long term interactions with others, and is involved in personally-relevant activities, so that the blocked goals are quite important. Given this definition, a space station or vehicle is a primary environment and perceived crowding is very likely.

Figure 5: Personality Trait of High Sensation Seeking



Several people in a confined area can be labeled as crowding because the individual loses control over when and how often he interacts with others. (As a consequence of isolation, he also has few choices regarding who is available for contact.) The withdrawal mentioned earlier in the section on other confined and isolated environments may be a response to the overload caused by the continual presence of other people (e.g., Schmidt and Keating, 1979).

Since crowding is a perception, the person can be distracted. Studies have shown that various tasks, activities, social conditions, or interesting environmental features such as pictures can focus attention away from density, making a person feel less crowded (summarized by Schmidt and Keating, 1979). The heavy workload historically experienced by astronauts and even the large amount of time they spent looking out the spaceport may have distracted them and minimized their impression of being crowded.

III. SOCIAL ISOLATION

When a space crew departs from Earth, they also leave behind families, friends, and peers. This separation from social support systems could be termed social isolation. Our concern here is with the consequences of this type of isolation on how crew members perceive (and react to) environmental demands.

One of the major findings in the literature is the specificity of social support (Bankoff, 1981, as cited in Lieberman, 1982). There exist implicit norms about who is the appropriate person to help in certain situations. If this person cannot help, then no matter who else offers, psychological rejection is experienced (Lieberman, 1982). Another study (Brown, 1981, as cited in Lieberman, 1982) reiterated this result. They found that the spouse is the key confidante and that when this person is not available, another confidante is not an effective substitute. The second best support in reducing psychological distress comes from friends (Sherman and Lieberman, 1981, as cited in Lieberman 1982). An earlier study found spouses were the primary helpers in coping with worries and friends were the primary social resource in dealing with unhappiness (Gurin et al., 1960, as cited in Lieberman, 1982).

An ongoing line of research by Lieberman has shown that the more active, intimate, and dependable the social support, the lower the role strain experienced. If social support is perceived as dependable, role strain is less in occupational, marital, parental, and economic roles (Lieberman, 1982).

Several studies have shown that unfortunately, if individuals become overly concerned that others may evaluate them negatively, these individuals may suppress affiliative or supportive needs in favor of social isolation (Zimbardo, 1982). Since the cohabitants of a space vehicle or station will be required to fulfill all of a crew member's interpersonal needs, he may well become sensitive to their possible disapproval and withdraw from interactions. It has also been found that people experiencing negative stress help others less and are less likely to engage in positive social behaviors (Cohen, 1980).

The implication of these findings is that the occupants of a space craft are not going to have their usual resources, their social support network, readily available to help them handle the extreme demands of living and working in space. As mentioned earlier, some individuals are more likely than others to seek the assistance of an extended social support network than others.

One focus of future mission planners could be to identify those individuals and determine whether the "specificity" issue is less relevant to them. That type of person may be better suited, then, to cope with extended social isolation as it will be experienced during long-term space flight. The inflight environment may need to be structured to provide for frequent non-evaluation periods and to encourage the development of mutually supportive friendships. Another implication is that the mission control hierarchy needs to be aware of the need for frequent and confidential contact between crew members and their spouses or close friends during the ongoing mission (Christianson and Talbot, 1986).

IV. SENSORY DEPRIVATION

Sensory deprivation, as defined earlier in this chapter, is a drastic reduction in the level and variety of a person's typical degree of stimulation from his environment over an extended period (Goldberger, 1982). Although some researchers have claimed that sensory deprivation is not an issue for extended spaceflight environments (Berry, 1972; Santy, 1983), personality research in particular suggests differently. Although many of the moderating variables in deprivation experiments have been difficult to reduce to personality categories due to the extremely comprehensive nature of this phenomenon, several important moderating traits have been identified. To quote Goldberger directly, "...such personal characteristics as overall ego strength, tolerance for primary-process ideation, field dependence-independence, and sensation seeking needs have been consistently identified as meaningful individual difference correlates..." (p. 413, 1982). High sensation seekers, for example, have been shown to have a poor tolerance for low levels of sensory stimuli (e.g., Zuckerman, 1983).

Laboratory studies of sensory deprivation (as summarized by Goldberger, 1982) have found that subjects frequently experienced boredom, apathy, peculiar sleeping patterns and a state of motivational loss. The mind seemed to wander, with lessened concentration and attention. Logical, directed thinking was impaired, as was performance on tasks requiring complex, self-directed efforts. Very simple performance, such as rote learning or memorization, was improved by sensory deprivation. Findings of boredom, restlessness, insomnia, task performance difficulty, poor concentration, mental inertia and so on, have been reported in isolation and confinement (Bennett, 1983; Santy, 1983). Therefore, selection criteria for future space travelers may need to include some measure of how well individuals can tolerate the same physical surroundings, people, and tasks for weeks or months at a time. Conversely, space environments and schedules should be designed to minimize sensory deprivation.

V. SENSORY OVERLOAD

When bombarded by higher than usual levels of sensory stimulation, a person experiences sensory overload (Goldberger, 1982). Spacecrew members may be subject to sensory overload when receiving several different types of information simultaneously. Experimental studies on overload have been of much shorter duration than those focusing on deprivation, which may simply reflect the fact that overstimulation is more aversive than understimulation (summarized by Goldberger, 1982). Overstimulated subjects are highly aroused, show intellectual and cognitive impairment, experience time distortion and body distortion, and report vivid imagery (which may become hallucinations) in the course of such experiments (Goldberger, 1982). Because so many sources are clamoring for attention, individuals may experience difficulty in picking out the most salient cues for prompt and effective action. Sensory overload is characterized, then, by sensory input beyond one's ability to control.

Again, several parallels exist between laboratory results and findings from real-life isolated and confined environments. For example, time distortion and hyperarousal in astronauts has been widely reported (Santy, 1983). Cognitive impairment of various types has been observed in several confined environments (Kanas, 1985). Selection of future astronauts could consider which personality types are most likely to remain calm and controlled when faced with sensory or information overload. Because previous astronauts have often had an extensive flying background, it may have been assumed that they had already proven their ability to handle overstimulation during aerial missions. The spaceflight environment could also be structured to optimize the available sensory input and to avoid information overload during tasking.

VI. PHYSICAL DANGER

Exposure to physical danger has been found to trigger certain human responses. Hypervigilance is a frequent response. The person attends to all sorts of threat cues in an effort to make a thorough search and appraisal of the situation and their options. Because they are paying attention to both relevant and irrelevant threats, however, much of the time and energy they could have spent in finding a solution is wasted. Along with indiscriminate cognitive activity, people rely on oversimplified categories and decision rules when deciding on a course of action (Janis, 1982). For example, in emergencies such as a fire, a simple decision rule is to do whatever others are doing. If a strong authority figure is present and gives orders, then the decision rule could become to do whatever he says. Under conditions of high fear, social dependence increases. People strive to avoid being separated from companions, prefer contact with strong and reassuring authority figures, and increase compliant behavior (Janis, 1971, as cited in Janis, 1982).

The primary reason for having a flight-trained astronaut with a military background in command of space missions could be his presumed experience with successfully handling short-term physical danger. He is expected to be the authority figure giving orders to successfully resolve inflight emergencies. Coping with environmental demands such as emergencies for a short period may be markedly different than coping with emergencies or physical demands for a longer period, however. If a flight-trained astronaut reacts to danger with hypervigilance (which sounds remarkably like hyperarousal, a previous response to space), he will be very susceptible to exhaustion during long missions. If he is always expected to be the strong authority figure, he may also be susceptible to emotional exhaustion over a long period.

VII. GENDER DIFFERENCES

The question of whether men and women should be together in space for extended periods of time is an emotional issue, and one that this chapter is not going to address (see Santy, 1983, for a brief discussion). However, since women have participated in the space program, some established gender differences deserve mentioning. Women seem to adjust well to close social interchanges and to have smaller and more permeable personal spaces (Helmreich et al., 1980; Schmidt and Keating, 1979). Studies have also shown that, in conditions of high social density, men formed fragmented, competitive groups while females were more cohesive and cooperative (summarized in Schmidt and Keating, 1979).

These gender effects may be due to different gender norms in our society. Females are allowed to be expressive, let others close, and show their reactions to social density, which would make the formation of cohesive groups based on common feelings more likely. Men, however, are not permitted to express their feelings, may consider closeness to be less than masculine, and may attempt to repress their negative emotional reactions to crowding or other spaceflight conditions. Such repression frequently leads to a fragmented group orientation (Schmidt and Keating, 1979).

Women have also reported a greater tendency to relax using expressive leisure activities, such as reading and singing. Significantly more men, on the other hand, stated that they preferred more physical leisure activities, such as sports (Runge and Helmreich, 1978, as reported in Helmreich et al., 1980). These findings suggest that women may adapt better to physical confinement than men because they typically need less room to relax.

VIII. ORGANIZATIONAL DEMANDS

Since the individual crew members of a space station may not all have experience with a military, hierarchical command structure, this unfamiliarity may lead to strain between people with and without military experience. (The same idea applies if the structure is atypical to those with a predominantly military background.) Role ambiguity, particularly in a work setting, is likely to be experienced as negative stress (Cooper, 1985). A perceived lack of support from one's superior or superiors is also consistently viewed negatively (Cooper, 1985). Responsibility for subordinates and their safety is a further potentially significant occupational stressor (Cooper, 1985). In addition, high work demands can result in overload, so that workers become tense, fatigued, and unable to relax (Cooper and Sloan, 1982, as cited in Cooper, 1985). Job underload associated with repetitive, routine, boring, and understimulating tasks has been associated with negatively experienced stress (summarized in Cooper, 1985).

Certain members of the crew may not even be communicating in their native tongue and alienation or significant misunderstandings may result. For example, Bluth (1981) discussed the fact that the Czech cosmonaut Vladimir Remek was reportedly uncomfortable with his Russian crewmates due, in part, to language difficulties. (One effective way to reduce friction is humor, yet humor is usually one of the last things learned in a foreign language.) Several researchers have suggested that, as crews become more and more heterogeneous, interpersonal conflicts may become more and more likely (e.g., Helmreich, 1980).

CONCLUSIONS

A CRITIQUE OF THIS ANALYSIS

This chapter has advocated a stress-focused analysis of the interactions between personality and environment during a long duration space mission. This approach is subject to both positive and negative criticisms.

Information from several different fields of study has been incorporated here. The advantage is that the resulting picture should be well-rounded; the disadvantage is that the inputs from each field may be somewhat distorted either to facilitate compilation or because the "best" information from each field was not objectively identified.

There are three major problems with the current analysis. First, the effect of personality and environmental conditions on perception were examined on a one-by-one basis. For instance, we looked at how an extrovert responds to social isolation or how someone with an internal locus of control responds to a lack of job autonomy. The factors within either the personality or environmental category were not combined. For example, how does an extrovert react when faced with a combination of social isolation and physical danger? Does an intrinsically-motivated sensation seeker deal better with sensory deprivation from the same monotonous surroundings better than a sensation seeker who is not intrinsically motivated? Unfortunately, no research was found that combined several factors in this type of analysis.

Second, other important interpersonal factors were not considered. For instance, that crew members might come from different technical or cultural backgrounds and be trained differently or separately were discussed but not added into the final analysis. In particular, group dynamics and interactions were not mentioned. Other researchers (e.g., Wood and Dunivin, 1985) have discussed groups, and this work needs to be incorporated with the individual and environmental differences identified here in an interactional analysis.

Third, this research was preliminary. It was intended to raise more questions than it answered. Hopefully, it should evoke responses from other behavioral scientists. The diverse studies cited here put together a patchwork quilt with several holes. Inferences and outright guesses were used to patch a few of these holes. More research is definitely mandated and this research needs to be carefully **targetted** at the interaction issue.

RECOMMENDATIONS

If we are planning an extended, manned foray into space (whether in a space station or a traveling, goal-directed vehicle), we **must** be aware of the complexity of the human element as a living, breathing, dynamic factor that will continually interact with the spaceflight environment.

Other researchers have made suggestions as to who should be sent into space. For example, Helmreich and colleagues (1980) suggested that androgynous individuals would be very flexible in approaching the diverse circumstances to be encountered in a space environment. They also suggested that the optimum personality profile to send into space should include a high work, high mastery, low competitiveness motivation. Given the discussions in this chapter, however, these recommendations could be termed simplistic.

We have suggested that the ongoing mutual interaction between the people we send into space and their immediate environment be carefully considered in an interactional analysis. This chapter has specifically looked at how personality traits probably interact with different facets of the environment. This is only one of many possible approaches, of course.

What scientists in several fields are learning currently about people either individually or in groups needs to be incorporated into ad hoc spaceflight planning. For example, an expert on island biology who very recently studied the differences between small groups that did and did not survive confinement on small, dangerous islands discovered that the single most important success factor was a strong sense of purpose (Budiansky, 1987). In addition, he pointed out that survivors tended to have harmoniously worked or lived together previously, had a cultural tradition of noncompetitiveness and politeness, and were very willing to assume new roles. Can we afford to ignore this information because these were not spaceflight simulations or because the groups were not formed to accomplish technical tasks? No, we cannot.

Agreeably, our space program has been successful. American astronauts so far have been uniquely qualified both psychologically and technically to meet the demands of a spaceflight environment and have been shown to experience mainly positive emotions from those situations. The picture changes markedly, however, when we send people into space for extended missions. Mission planners need to consider the types of people being sent into space, the situational factors they are likely to experience, and the way that both person and situation will interact. For example, the astronaut with a military pilot background is readily frustrated when his control of the situation is limited. Given mission and personnel constraints, he may frequently experience far less than optimal control. With crews of diverse backgrounds and temperaments, some interpersonal friction is unavoidable. The flight commander who is leery of emotionally-charged and ambiguous interpersonal conflicts may not have an extensive repertoire of skills to resolve such situations. If this is the best man to command a spacecraft, however, then the situation may be restructured to better fit his strengths or he may be given preflight (or even inflight) training on identifying, confronting, and resolving interpersonal conflicts.

With forethought, we can alter factors likely to increase negative stress reactions among spacecrew members. This planning should be based on the interaction between people and their surroundings. The goal of this planning is not only to reduce the likelihood of maladaptive responses such as withdrawal, acting-out behavior, and emotional exhaustion, but to increase the work productivity and personal satisfaction of our space pioneers.

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SLEEP AND PERFORMANCE

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The need for and effects of sleep have major implications for all aspects of our lives. Most of us regulate our lives and adjust our sleep/wake cycles in consonance with external events such as light and darkness, mealtimes, and alarm clocks and watches. Over the billions of years that man has been evolving, he has become increasingly tied to a 24-hour activity cycle that parallels the earth's rotation. This biologically based 24-hour cycle is called a circadian rhythm. As discussed elsewhere, circadian rhythms involve daily cyclical changes in body temperature, blood pressure, blood-plasma volume, hormonal secretions, and other bodily processes (Smith, Sarason, & Sarason, 1986; Winstead, 1987). One of the other processes influenced by circadian rhythms is sleep, which occurs during the low point of the temperature cycle. In humans the sleep cycle changes from polyphasic, which is characterized by several sleep/wake cycles during the day, as an infant, to a monophasic cycle, characterized by one long sleep period each day, as an adult.

Although sleep has been systematically studied for many years, there is little clear evidence supporting an overriding reason why we must sleep. Some studies have stressed nervous fatigue or exhaustion, some have emphasized the accumulation of metabolic waste products in the brain and body, and other studies focus on the accumulation and discharge of hormones in the body, but none of these studies has conclusively shown why humans must sleep or why we sleep as much as we do (Foulkes, 1966). There have been two major approaches to the study of sleep. One treats sleep as a physiological response in relation to changes in environmental variables and primarily studies the composition (physiological phases) of sleep. The second approach treats sleep as an operationally defined variable in terms of the amount of sleep an individual gets as a result of that individual's sleep need. The emphasis of these studies has been on specific functions during wakefulness and includes functions such as learning and memory, problem solving, stability, and somatic (bodily) functioning. Research using this approach has focused on studies of total or partial sleep deprivation. Researchers have performed sleep deprivation studies in animals where the subjects have died as a result of deprivation in excess of ten days (Kleitman, 1963). Post-mortem analyses of these animals tends to find a degeneration of the tissue in the brain and other body organs. There are, however, no documented studies of humans who have died of lack of sleep (Hales, 1981). Nevertheless, the animal studies do suggest that sleep may have a physiologically regenerative function.

Sleep deprivation studies generally show that humans characteristically suffer a "loss in efficiency in mental and physical functioning, irritability, and tendencies toward perceptual distortion and ideational confusion" (Foulkes, 1966, p. 10). Baekeland and Hartmann (1970) affirm these findings with their research where they found that the effect of total sleep deprivation on behavioral tasks is a function of the amount of deprivation and the time of day. The behavioral aspects commonly noticed included reduced levels of arousal correlated with lapses in performance efficiency. The performance decrements were noticeably increased when the tasks were boring and unduly complex. Baekeland and Hartmann further reported that after 40 hours of deprivation subjects experienced increased irritability, lack of perseverance, and perceptual distortions. The perceptual distortions were most apparent during periods of relative inactivity and included visual, temporal, and cognitive perceptions.

Two well known examples of prolonged deprivation occurred as attempts to set records. In 1959, Peter Tripp, a disc jockey, remained awake for 200 hours as part of a charity fund-raising event. His physiological and psychological behaviors remained relatively normal to observers until the last days of his feat when he was observed to hear sounds that didn't exist and began to show signs of paranoid behavior (Smith, et al., 1986). A second case occurred in 1964 when a high school student decided to stay awake to set a record as part of his science fair project. Randy Gardner stayed awake for over 260 hours. While showing signs of physical fatigue, he did not show signs of bizarre psychological change. After 15 hours of sleep during his first night, he returned to a normal pattern of sleep the second and subsequent nights (Smith, et al., 1986). This a finding that is further supported by the findings of Oswald (1962) who posited that men/women in space could or may adapt to a schedule where they would only sleep once a week for 14-15 hours.

While there are pronounced effects that result from sleep deprivation, there are also wide variances in the amount of sleep required by individuals. The average person sleeps approximately seven and one half hours each day. About five percent of the population sleeps less than six hours per day and five percent sleeps longer than nine hours per day. In the extreme case, researchers have studied individuals who normally sleep no more than thirty minutes each day (Moore-Ede, Sulzman, and Fuller, 1982). Baekeland and Hartmann (1970) believe that short sleepers evolve as a result of personality development and psychological style. They identify personality differences that they feel are characteristic of short sleepers: ambitious; active; energetic; cheerful; conformist in opinions; and sure about career choices.

On the other hand, Moore-Ede et al. believe that long sleepers are: shy; introverted; slightly anxious; mildly depressed; passive; and unsure of themselves. These differences are not widely accepted, however, as Webb (1975) takes issue with them based on his studies from which he concluded that there were no significant personality differences between long and short sleepers.

In a study of subjects who were placed in an environment free of time cues and on a self-scheduled sleep routine for up to 180 days, Czeisler, Weitzman, Moore-Ede, Zimmerman, and Knauer (1980) found that sleep time was not dependent on prior wakefulness, but rather on when an individual went to sleep and when this occurred in relation to his/her cycle of body temperature. In an environment free of time cues, these body temperature cycles tended to synchronize over the long term and individuals developed near-24-hour sleep/wake and body temperature cycles. This is supported by the finding of Lavie and Zomer (1984) that circadian rhythms and body temperature seem to have similar periodicities, but can become desynchronized over the short run when an individual is isolated from time cues (see also Winstead, 1987). Sleep periods tended to be longer when begun at or after peak body temperature (and alertness) points. On a free schedule for more than two months and without time cues, subjects tended to adjust and develop consistent bedrest/activity patterns.

In another study (Cairns, Knowles, and MacLean, 1982), the authors discovered there was a prevalent diurnal (daily) variation in efficiency on behavioral tasks occurring in conjunction with and as a result of work shift changes while the circadian rhythm and body temperature cycles adapted. These data were supported by Roth, Roehrs, and Zorick (1982) who reported impaired performance, changes in mood, and increased napping among shift workers engaged in phase shifting. The trough of the temperature cycle normally occurs at 0400 to 0500 and the peak at approximately 2000 to 2100. Findings indicate that errors and/or low output are greater on early morning shifts (particularly the 0400 to 0500 period when the body temperature is at its lowest point). The requirement to change the "normal" hours that an individual has adapted to causes a major disruption in work efficiency. The performance on this new schedule is especially susceptible to errors in the 0400 to 0500 time frame for a person who has been used to a daytime schedule. The time would vary in a proportionate manner with someone changing from a night to a day shift. Hales (1981) cites data that shift workers average only 5.6 hours of sleep each day, while the average person sleeps 7.5 hours out of every 24 hours. Studies of railroad workers who had their sleep/wake cycles inverted (switched 12 hours in phase) indicated that approximately three weeks were required for adjustment to the new shift (return to

the same level of performance/efficiency). Disruptions (acute changes) in sleep cycles impaired signal detection performance, but shifts away from the 2400 to 0800 sleep cycle did not impair work performance if adequate time was allotted for adjustment.

Roth, Roehrs, and Zorick (1982) found that not all tasks are equally sensitive to manipulations of sleep, and that tasks which are long and monotonous are typically the most sensitive to sleep changes. The major effect on an individual's mood as a result of sleep changes seems to be just a subjective measure of sleepiness. An important finding was that both partial as well as total sleep deprivation led to physical performance decrements in waking activity, and that as little as two hours of sleep loss produced these waking decrements. These decrements could be overcome by increased task motivation, however. For example, performance decrements can decrease or disappear with optimum conditions of subject motivation. This compensation effect can overcome performance decrements for total sleep deprivation for a short time, but it does not reduce the other effects of sleep loss, such as irritability, perceptual distortion, and confusion. Sleep deprived subjects who were put into an environment that was conducive to sleep were unable to stay awake when motivated and instructed to do so.

Another area of interest is sleep fragmentation. Roth, Roehrs, and Zorick (1982) refer to this as a disruption of nocturnal sleep with sleep loss. There has been little systematic study of its effects. The most common application of this idea would be the effects of noise on sleep that fall short of waking the subject. Evidence suggests that noise presentation during sleep might result in performance decrements and changes in mood (Roth, et al., 1982). Data do suggest that continuity of sleep is important for maintaining optimal waking performance. Other findings indicated that individuals experiencing circadian phase decays, phase advances, or irregular sleep/wake cycles have difficulty with sleep onset and maintaining adequate wakefulness during the day (Roth, et al., 1982). People engaging in shiftwork feel these disruptive patterns the most and exhibit impaired performance, mood changes, and increased napping (Roth, et al., 1982). The Multiple Sleep Latency Test (MSLT) seems to provide reliable measures of the effects of sleep deprivation and sleep extensions. Another profitable area of study in which there seems to have been little conclusive research is sleep extension. On a long-duration mission the opportunity for greater than average amounts of sleep for prolonged periods of time may have effects that are at present unknown.

Wever (1984) explored the interrelationship of sleep and wake cycles and found that the wake cycle duration had direct effects on the duration of the following sleep cycle and that duration of that sleep cycle determined the duration of the following wake cycle. He also discovered sex differences in sleep/wake cycle duration. When males and females were placed in isolation (no reference to time cues), females were found to have a shorter total cycle by an average of 28 minutes. However, the proportion of sleep was also different: females would stay awake one hour and forty-nine minutes (1:49) less than males and sleep one hour and twenty-one minutes (1:21) longer. This sleep fraction is 18% larger for females. These experiments with free running cycles under constant conditions indicated a high degree of organization in the temporal sequence to the sleep/wake alternations. There is highly significant evidence for negative serial correlations of successive sleep/wake cycles.

Another issue that holds potential impact for long-duration space flight is the sexual dream. Depending on the make-up of the crew on a mission, the opportunity for normal sexual activity may be substantially decreased or nonexistent. This issue is especially relevant for men and women who are used to active sexual lives and will be facing long periods of sexual deprivation and separation from their sexual partners. The resulting occurrence of sexual dreams should be anticipated and considered a normal reaction to the environment. For males the nighttime erection is so common that its absence is a warning sign for impaired sexual health. In various adolescent age groups the incidence of sexual dreams that result in nocturnal orgasm or "wet" dreams varies from 28 to 80 percent of the population (Hales, 1981). According to Kinsey, Pomeroy, and Martin (1948) 99 percent of American college educated males have occasional nocturnal seminal emissions. These decline or stop after marriage but are likely to recur after separations. For females, nearly 37 percent reported sexual dreams that led to orgasm, with the frequency increasing during periods of separation or confinement (Oswald, 1962).

Conclusions

The information in this section has been gathered from studies performed in the earth environment free of many of the unknown influences of the space environment. The conclusions made and the considerations offered are the author's best attempt to lend an operational flavor and application to this information as it might be used in planning for long-duration space missions.

There is not a definite answer about why we need to sleep, but most research shows that it is an important consideration in everyone's life. The average person needs approximately 7.5 hours of sleep in each 24 hour cycle, but large individual differences exist. CONSIDERATION: Crewmembers should be evaluated individually for their sleeping habits and need for sleep.

Although there is little agreement among researchers, there may be personality traits that are associated with different individual needs for average sleep duration. CONSIDERATION: If this information is true, there may be personality differences between "long" and "short" sleepers who might be incompatible in the confined environment of a spacecraft over a long-duration mission. This could be an ancillary issue for crew selection.

Attention to detail is greatest early in the waking day. Later in the waking day the tendency is to perform tasks faster, but less accurately. CONSIDERATION: Perhaps those tasks which require the most attention to detail should be scheduled earlier in the waking day.

Short-term and intermediate memory usually decline over the waking day, while long-term memory abilities increase. CONSIDERATION: One-of-a-kind type tasks (experiments and projects) should be scheduled early in the waking day, while more routine tasks be scheduled later. In addition, tasks requiring high cognitive ability (mental processes) should be accomplished early in the waking day.

When the cost of an error may be critical, a permanent shift system should be employed. Research has shown that rotating shifts have little if any benefit since they lead to rhythmic disintegration. CONSIDERATION: Workers on each shift should follow a consistent work, leisure, and rest routine and shifts should be stabilized. Stabilizing shifts avoids problems with sleep/wake, gastrointestinal, and cardiovascular disorders, while promoting mental health and job satisfaction.

Zeitgebers are external synchronizers for circadian rhythms. In space the usual dark/light cues will be altered. Although there are conflicting opinions, one researcher believes that it is possible that people would develop a pattern of sleeping 14-15 hours just once each week. CONSIDERATION: Attempts should be made to keep as many zeitgebers as possible (that can be controlled by scheduling) consistent with normal wake/sleep cycles. Sleep patterns in this environment may be radically different from all those found in ground based studies and may require maximum flexibility in scheduling crewmember activities.

The amount of sleep required is independent of the number of previous hours awake, but is dependent on when the individual goes to sleep and the circadian rhythm of body temperature. CONSIDERATION: Body temperature monitors can indicate optimum sleep/wake cycles and should be used in long-duration space missions to provide information to help minimize errors and optimize performance.

Partial deprivation of sleep (as little as two hours) has almost the same decrement in performance as does total deprivation. Performance decrements will be noticed to a larger extent in monotonous tasks. CONSIDERATION: Careful monitoring of sleep cycles will help reduce the effects of sleep deprivation.

Partial or total sleep deprivation may occur for unknown lengths of time in the space environment. For short periods of time the overall effect of sleep deprivation should not be a major concern as studies have indicated that one long night of sleep following even long periods of deprivation has been sufficient for most individuals to recover to normal sleep patterns. CONSIDERATION: If sleep disorder does occur, the recuperative powers of the body after one long night sleep will be sufficient to help put the individual back on a normal diurnal cycle.

Sleep fragmentation is the disruption of nocturnal sleep without actually waking the individual. In the confined environment of a spacecraft, it is likely that noise and other activity may provide constant minor disruptions in the continuity of sleep. CONSIDERATION: To the extent possible there should be an attempt to isolate crewmembers that are sleeping from the working environment of the spacecraft. It is further possible that a reaction to sleep fragmentation could be sleep extension, where individuals will spend extended periods asleep, the effects of which are presently unknown.

Sex differences exist in the sleep/wake cycles of humans. Women require as much as 18% more sleep than men, while at the same time their total daily sleep cycle is shorter. CONSIDERATION: Differing cycles of sleep/wake activities of men and women may make mixed sex crews less practical on long-duration space missions. Certainly, separate scheduling or tasking cycles seems appropriate.

Sexual dreams are normally occurring events for humans. For individuals who have led active sex lives, separation, confinement, and the absence of sexual activity are more likely to result in sexual dreams leading to "wet dreams" (orgasm). CONSIDERATION: Crewmembers should be briefed that sexual dreams leading to orgasm are likely to occur. This may allow them to deal more effectively with the social stigma attached to these occurrences.

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STRESS INFLUENCES IN LONG-DURATION SPACE FLIGHT

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INTRODUCTION

While the investigation of stress as it impacts on the long duration space flight has received scant attention in the behavioral sciences literature, the general topic of stress in all sources of literature has been among the most popular research topics in the past decade. Literally thousands of references are available on the nature of stress, the impact of stress, the relatedness of stress to a vast host of other issues, the mediators of stress, and the management of stress. Perhaps the lack of attention to stress issues in long-duration space flight finds its roots not in the lack of stress-related issues in space, but in the resistance of mission planners, managers, and flight personnel to scientific advice from personality, social, and clinical psychologists (Helmreich, 1983). The roots of this are subject to debate, but should not serve to hinder future, carefully devised strategies to aid American space flight. The ideas presented in this paper are founded in the behavioral sciences literature and are provided to assist planners in their extraordinarily difficult job of planning long-duration space missions. The focus of this paper will be on the implications of the vast body of stress research on the potential problems of planning and executing long-duration space travel. Necessary assumptions used throughout this paper will be carefully separated from more objective empirical findings.

It seems particularly important to examine the topic of stress in this stressful time for the entire national space program. Not only are there a multitude of environmental and personal issues that must be dealt with stemming from the Challenger tragedy, but as space missions gain in duration, we need to rethink most issues about the abilities of our crews to handle the wide range of stressors that will be present (Harrison & Connors, 1985). The behavioral sciences literature has been distilled to focus on issues that seem to be of concern to space voyagers. For example, the effects of old age create a whole set of unique stressors that are not envisioned to be among the problems facing the first Mars crew members. Yet, unlike the previous missions (including the longer Skylab ventures), stress issues that develop from working with a group in a confined space for such an extended period of time are certainly within the scope of this paper.

Stress - a note on definition. Too many definitions of stress exist. In fact, many researchers have commented on both the frequency of the use of the term, and the general imprecision of its use (Appley & Trumbull, 1967; Cofer & Appley, 1964; Kahn, 1970; McGrath, 1970; Sells, 1970; Weitz, 1970). A few selected definitions provide a necessary framework for our understanding.

McGrath (1976, p. 1352) defined it thus: "there is a potential for stress when an environmental situation is perceived as presenting a demand which threatens to exceed the person's capabilities and resources for meeting it, under conditions where...(the person)...expects a substantial differential in the rewards and costs from meeting the demand versus not meeting it". Perhaps the most widely noted researcher in this area, Selye (1956), defines stress as "the nonspecific response of the body to any demand" (p. 36). He goes on to suggest that complete freedom from stress is death. Other researchers frequently posit a prerequisite for the occurrence of stress to be a perceived imbalance between the person's subjective capacity to deal with a demand and the subjective task demand itself (Lazarus, 1966; Schulz and Schonpflug, 1982). That is, stress is generally seen as a relationship between the person and the environment. Definitions of stress generally contain the element of a subjective anticipation that the person cannot easily adapt. McGrath (1970) has suggested that one other trend that appears to be common in recent definitions is that stress may be a consequence of two opposing type of demands: overload and underload.

Closely connected to the conceptualization of the type of problems that will face long-duration space missions, Beehr and Bhagat (1985) add the dimension of uncertainty. They suggest that it is the uncertainty of being able to cope, combined with the duration of the demand, that produces the stress. They also suggest that the element of perceived importance of the situation is crucial to the person-environment fit. If a stressor were to begin in the third month of a three- or four-year mission, and if one of our common strategies for stress management (avoidance) were not available because of the confines of the vehicle, this definition carries definite implications for preplanning. While these selected definitions only begin to narrow the scope of the issue, some general trends in the conceptualization are apparent. Before proceeding with specific notions, it is necessary to review selected models of stress to further understand the concept.

MODELS OF STRESS

While definitions of stress abound, comprehensive models are not so widely available. Perhaps the most noted model for understanding the concept is that of Selye (1936, 1956). In the course of experimentation with rats, he noticed physiological reactions as manifestations of the body's mechanism of defense against a wide variety of stimuli. The entire syndrome was called the **General Adaptation Syndrome (GAS)**. The GAS is made up of three stages:

Alarm stage. The body's initial reaction to a threat in the environment. Virtually every organ in the body responds to make ready for "fight or flight". Most of the acute stress diseases correspond to the alarm stage. In many instances this stage is

short-lived. An example might be the reaction of the body to the initial shock of jumping into an ice-cold lake.

Resistance stage. This stage occurs when the stressor is persistent and results in temporary (generally) physiological or mental changes. In this stage the organism's full adaptation to the stressor is present and is generally followed by the consequent illusory improvement and disappearance of symptoms. At this stage there is a concurrent reduction in resistance to other stimuli. In the current analogy about the ice cold lake, one is generally able to adapt to the extremely cold lake and fight off the negative effects of the cold stimuli.

Exhaustion stage. This stage occurs when the organism's physical and psychological resources are unable to adapt and are overcome. Since adaptability is finite (Selye, 1982), exhaustion follows if the stressor is sufficiently severe and prolonged. In the analogy, if one were to remain in the ice cold lake for an extended period of time, the ability to resist would soon be overcome and death would occur. In the space environment, the exhaustion stage would manifest itself in fatigue, disease, disability, and even death.

Adaptation energy is finite. Experiments with animals have shown that stressors can be tolerated for only so long. Selye (1982) recently suggested that we don't even know precisely what is lost, but it is apparent that it is something other than a food source since even well-fed subjects experienced similar reactions. Selye has also shown that this stress syndrome is fundamental to all higher forms of animals. Finally, Selye cautions that these three stages are not as distinctly separate as they may appear on paper. They are really only artificial divisions of a naturally continuous process. The transition from one to another is gradual.

A model that fits the more typical working environment is one presented by Ivancevich and Matteson (1987). It is designed to illustrate the link between stressors, stress, and consequences. The model divides stressors (from the work environment) into four categories: physical; individual; group; and organizational. The model also introduces intervening variables called moderators. A moderator is a condition, behavior, or characteristic that qualifies the relationship between the two variables. The effect may be to intensify or weaken the relationship.

The postulated moderators seem to act as buffers to stressors and have enjoyed varying degrees of research validation. This author maintains that the work by Maddi and Kobasa (1984) described later in the paper merits consideration as an important addition to the list of potential moderators. Maddi and Kobasa have suggested that a personality dimension they call "hardiness" is a powerful moderator.

Finally, the Ivancevich and Matteson model incorporates six

categories of the effects of stress. These consequences include subjective, behavioral, cognitive, physiological, health, and organizational. These bear some elaboration from the model presented below since only features of it will have direct relationship to the study of long duration space flight. Subjective effects that might be of consequence include: anxiety; aggression; apathy; boredom; depression; fatigue; loss of temper; low self-esteem; nervousness and feeling alone. Behavioral effects that are possible include: emotional outbursts; excessive eating; impulsive behavior and nervous laughter. Among the cognitive effects we might anticipate: inability to make sound decisions; poor concentration; short attention span; hypersensitivity to criticism and mental blocks. While not the focus of the paper, certain physiological effects are possible: increased glucose levels; increased heart rate and blood pressure; dryness of the mouth; sweating; dilation of the pupils and hot and cold flashes. Organizational effects include: low productivity; alienation from co-workers; job dissatisfaction; reduced organizational commitment and reduced loyalty. A table showing the key components of this model follows.

STRESS AND WORK: A WORKING GUIDE

STRESSORS	MODERATORS	CONSEQUENCES
PHYSICAL ENVIRONMENT Light, noise, temperature polluted air	DEMOGRAPHIC Age, sex, education physical well being	SUBJECTIVE Anxiety
INDIVIDUAL STRESSORS Role conflict, role ambiguity, work overload responsibility for people, lack of career progress, and job design	PSYCHOLOGICAL OR PHYSICAL EXPERIENCE OR PERCEPTION OF EXCESSIVE DEMAND ON THE PERSON	BEHAVIORAL Accident proneness
GROUP STRESSORS Poor relationships with peers, subordinates, and boss	COGNITIVE/AFFECTIVE Type A behavior, life change, social support	COGNITIVE Inability to make decisions
ORGANIZATIONAL STRESSORS Lack of participation, organizational structure, occupational level, and lack of clear policies		PHYSIOLOGICAL Increased blood pressure HEALTH (PHYSICAL AND MENTAL) Coronary heart disease ORGANIZATIONAL Lower productivity

While these models are not totally comprehensive, they are representative and, in general, fit our requirements for investigating the impact of stressors on long-duration space flight. At this point it is useful to begin a more complete review of the stressors that have direct bearing on space flight. The Ivancevich & Matteson model will serve as our primary framework.

ENVIRONMENTAL STRESSORS

There are certain factors in any environment that cause stress. Extremes of light, noise, and temperature can all be causes of both psychological and physiological stress. It appears that most of these factors are controlled within the design of space vehicles. However, other issues exist. One simple concept is that no two individuals can occupy the same area at the same time. Each person must have a "personal space" which is the area around him- or herself that maintains a physical and psychological integrity (Hall, 1966; Sommer, 1969). Each person establishes a personal space, one that is individually determined and subject to variations over time. The violation of one's personal space requires some degree of adaptation and may produce a perception of crowding.

Beyond this conception of a physical space need, individuals, especially in our society, have developed a need for privacy (the ability to control unwanted stimuli). There seem to be many important reasons for wanting privacy (Altman, 1975; Jourard, 1966; Westin, 1967). Among those cited include a need to reflect on past experiences, to preview upcoming events, to think of various role demands, to engage in rational thought, to enjoy creative fantasy, and to maintain one's identity. Loss of some degree of privacy not only leads to some amount of loss of Selye's concept of adaptational energy, but becomes another area of lost control which we shall see is a critical element of stress mediation.

Of particular relevance to the space traveler is the requirement to orient oneself to the environment. Indeed, our very understanding and reliance on the laws of gravity require us to reorient our relationship with the environment. Astronauts, though, are dependent on a strange environment that is at once different than one's whole experience on earth, generally more static, and potentially very hazardous. This "environmental understanding" is a sum of one's understanding about how an environment works. Astronauts also must develop some means to move through this environment with some competence in order to even begin feeling secure. When an environment is not secure, it becomes threatening with resultant anxieties and fears which in and of themselves further hamper our ability to deal with the new environment (Kaminoff & Proshansky, 1982).

The person-environment fit is a broad concept that also merits planning consideration. It is not a new concept, but its direct bearing on the analysis of stress has only recently drawn attention (Stokols, 1979; Zimring, 1981). The concept generally refers to the extent to which the environment accommodates, facilitates, or supports the needs and relevant behaviors of the individuals and groups which occupy it. Lack of fit causes stress by creating demands for adaptation which can exceed the individual's capacity to cope and still attend to other more goal-oriented demands. Several issues could have a significant impact. For example, the nature and intensity of the environmental stimulation, including the extent to which it can be predicted and controlled, is of considerable importance. Consider the simple variables of heat and cold and their controllability, if not critical or life threatening, as a tremendous psychological burden requiring adaptation (perhaps needlessly). Another issue relates to the previously mentioned concept of space. Spaces vary in their "boundedness" which may be defined as the extent to which architectural barriers restrict and direct stimulation and movement. The relative size of a partitioned area also has an influence on the relationship between the behavior and experience of the individual and the physical setting. Perhaps most germane is the flexibility of the setting. If there is built-in flexibility, person-environment fit can be adjusted as the fit becomes less comfortable. This is the concept behind modular furniture. When change is needed, the flexibility is built into the system.

Finally, and related to the flexibility issue are the features of clarity and appropriateness of meanings of the physical setting. As needs change, adaptations might increase the sense of control. "The flexibility of this setting, its boundedness, its size, and its differentiation, as well as the norms that pertain to its organization and use, may all contribute to the extent to which a person can escape from or even control the intense stimulation so that whatever stress is involved can be reduced or diminished" (Kaminoff & Proshansky, 1982, p. 384).

The perception of environmentally induced stress is highly dependent on the degree of predictability and control that is perceived by the individual (Averill, 1973; Cohen, Glass, & Phillips, 1979). Noise that is unpredictable produces poorer performance and lower tolerance to frustration (Glass & Singer, 1972), as well as more aggression (Donnerstein & Wilson, 1976) than equal amounts of predictable and controllable noise. Cohen (1978) speculates that unpredictable stimuli place greater attentional demands on the processing capabilities of the individual and therefore drain more adaptational energy.

INDIVIDUAL STRESSORS

Individual stressors have been widely studied, and among the most widely studied of these areas is "role conflict". Role

conflict exists when compliance with one set of job expectations conflicts with another set of expectations. In one study (Kahn, Wolf, Quinn, Snoek, & Rosenthal, 1964) it was determined that 67% of workers reported some type of role conflict, and those with higher levels of role conflict reported increased levels of job tension.

A related feature is that of "role ambiguity". It is defined as a lack of understanding of the rights, privileges and obligations that accompany a job. From the previously cited work by Kahn et al., ambiguity was found to be related to intellectual skill use, job knowledge, and job satisfaction. Clarification of rights, privileges and obligations prior to departure would minimize the stress potential brought about by role conflict and ambiguity. Additionally, features of team building help to clarify these areas. Meeting in groups to discuss job expectations aids clarification, too. The key is in knowing what is expected of oneself, what to expect of others, and knowing what others think is expected of themselves.

Santy (1983) has previously referenced the stressfulness of hyperarousal and overload. She pointed out that "several U.S. missions were jeopardized by unusual and unexpected behavior on the part of the crew and that at least one cosmonaut was noted to have unexpected inefficiency in operating his controls and had to be landed early" (p. 521). The inverted U hypothesis is perhaps the best explanation for the relationship between stress-induced arousal and performance (Hebb, 1955). This model suggests that after some optimal level of arousal, performance begins to diminish with ever-increasing levels of arousal. There are associated individual differences as well as clear relationships with level of task difficulty. The model can also help to understand the effect of low levels of arousal that might be associated with understimulation. This model further asserts that low levels of arousal produce low levels of performance. Most research has tended to support these findings (e.g., Atkinson, 1974) and even more recent work has found medical correlations at both ends of the continuum (Weiman, 1977). The clear message is the necessity for an ongoing monitoring of the individual's perception of his or her condition coupled with preplanned strategies for increasing or decreasing activity level.

Evidence exists to support a special requirement for monitoring those who have responsibility for other people (French & Caplan, 1973). This responsibility, beyond the responsibility over objects, contributed to greater job-related stress.

A considerable body of work has gone into the study of sensory deprivation, including the use of the method to screen potential candidates for the Mercury space program (Goldberger, 1982). Deprivation refers to the experimental conditions aimed at drastically reducing the level and variability of a person's normal stimulation from the environment for a relatively prolonged period of time. Goldberger summarizes the research in

this area suggesting that this condition induces an altered state of consciousness that has several psychological ramifications. Central to our focus, the psychological implications include: boredom; apathy; motivational loss; reverie; fantasy activity interspersed with periods of sleep; and attendant hypnogogic and hypnopomic phenomena. Attention and concentration deficits are also reported. Interestingly, self-directed efforts are most effected; some simple rote type tasks may even be facilitated.

In summary of his review of the literature, Goldberger suggests that while the findings have varied somewhat from study to study as a function of stimuli and mode of presentation, it appears that overstimulation tends to be more aversive than understimulation.

The last individual stressor, job design, can contribute to stress. Basically, a task can be managed in an infinite number of ways. Among them is a carefully designed scientific management approach that systematically sets about maximizing efficiency (Taylor, 1911). A more realistic approach takes into consideration the needs, values, and behavior patterns of the individual. Hackman and Suttle focus attention on the quality of work life which is "the degree to which members of work organizations are able to satisfy important personal needs through their experiences in organizations" (1980, p. 4). In a complex series of hypotheses, it follows that $JOB\ PERFORMANCE = ABILITY \times MOTIVATION$. Therefore, the job itself has motivating qualities and stress reducing potential. Hackman and Oldham (1975) suggest that skill variety (the degree to which a job requires workers to perform activities that challenge a range of skills and abilities), task identity (whether or not the job requires completion of a whole or identifiable unit of work), task significance (whether or not a job has substantial and perceivable impact on other people), task autonomy (the degree to which a job provides substantial freedom, independence, and discretion in scheduling work and procedures) and job feedback (the degree to which workers get information about the effectiveness of their efforts) all enhance motivation, increase satisfaction and effect performance.

Hackman (1970) reported the important job factors that induce stress. These issues include those dealing with time (sequencing of events and time allocation to specific tasks), actual properties of the task stimulus (complexity and ambiguity inherent in the task itself), and danger. High and low extremes of the first two elements create stress, while no evidence exists to support any problem associated with low levels of danger!

Careful review of the tasks of each crew member can serve to reduce stress caused by a non-motivating job. This is perhaps one of the easiest areas for intervention and clearly one of the central features of any prolonged space mission.

GROUP STRESSORS

According to Sells (1966), no single known social system closely approximates the demands that will be placed on extended space travelers. With the marvel of American technology sharply reducing the harsh environmental impactors, perhaps one of the greatest sources of stress will be the group itself. Coincidentally, the group could act as a social support system and serve as the greatest stress reducer. What are the important issues with regard to groups?

The effectiveness of any venture is a function of the relations of the group member's themselves. Argyris (1964) has suggested that good relationships among group members are a central factor in individual well-being. Poor relations include low trust, low supportiveness, and low interest in listening to and trying to deal with group issues (French and Caplan, 1970). The authors also concluded that large differences in power often causes stress. Steiner (1970) confirms that conflicts are sources of stress.

Miner (1980, as further detailed in this report) has suggested a number of potential group stressors. In a small, confined group, one is never alone. A crew member may have little "time off" from the "boss", and vice versa. Extensive contact between individuals of diverse backgrounds may cause the formation of subgroups, the splintering of task groups, repressive behavior, ostracism, etc. (Such problems have occurred in other isolation settings; e.g., Antarctic scientific teams, ocean expeditions, submarines, and space simulations.) Additionally, the crew is subject to social isolation. They are separated from their families, friends, enemies, and casual acquaintances and the needs commonly met by these various relationships may be ignored. This is especially critical since these relationships commonly serve as stress buffers. Members of the crew must therefore fill four different and frequently incompatible functions: work and friendship - evaluation and nonevaluative support (Bluth, 1982). Drawing from the literature on environment, researchers have recommended specific (albeit small) quarters be set aside to be the personal territory of each crew member.

On the other hand, groups may be a powerful source for warding off the effects of stress. One of the important aspects of group membership is that of social support (Johnson & Johnson, 1987). Social support is the exchange of resources intended to enhance the mutual well-being. It is the existence of people on whom one can rely for assistance, encouragement, acceptance, and caring. A natural support system is the family, which may be remarkable in our scenario by its absence. "Social support has been conceptualized to include quantity of connections (number of friends), quality (having people one can trust), utilization (actually spending time with people), meaning (the importance of friends), availability (the likelihood of having someone there when needed), and satisfaction with one's support" (Johnson & Johnson, 1987, p. 434). General cohesion is an indication of

reasonable social support; conversely, alienation indicates a lack of this construct.

ORGANIZATIONAL STRESSORS

There has been perhaps the least amount of study in the area of organizationally induced stressors. Yet, on the intuitive level, each of us can readily name issues that we normally attribute to stress caused by our organization. Some research does exist. Ivancevich and Matteson (1980) relate stress to organization structure and climate. Ivancevich and Donnelley (1975) maintain that a flat organizational structure produces less than a vertical structure with its inherent layers and bureaucratic decision making style. The authors suggest that a participative decision making pattern reduces stress. Most implications from this area are not seen as particularly likely to create problems once a mission is under way, except in the manner in which decisions are made in the larger organizational structure at mission control. In essence, the crew is merely a small part of the larger organization that must perform effectively. Indeed, organizational stressors may be most prevalent between flights when NASA is part of an even larger organization (the United States government). Dealing with the political decisions and making required adjustments in schedules and peoples' lives produce considerable stress on the entire organization. Special attention should be placed on these unique pressures.

SELECTED MODERATOR VARIABLES

As mentioned in the discussion of Ivancevich and Matteson's model, there appear to be certain moderator variables that enable different individuals to better cope with various stressors. These individuals frequently can adapt their behavior in such a way as to meet the stressor head-on. Others seem to be unable to resist the stressor. In this section we will explore selected moderator issues and their relationship to our problem at hand.

TYPE A BEHAVIOR PATTERN. Perhaps the most popularly cited moderator variable is that originally proposed by Friedman and Rosenman (1974). From the medical literature they discovered that traditional coronary risk factors such as dietary cholesterol and blood pressure could not explain or predict heart disease. They termed the pattern they uncovered as Type A Behavior Pattern. Type A behavior is characterized by competitiveness, hard-driving habits, impatience, achievement orientation, and being continually driven by time pressures. Type A individuals seem to be the major sufferers of the prolonged effects of stress.

On the other hand, Type B people tend to respond differently

to stress. They tended to be more relaxed and less easily irritated. They seem to have natural or learned immunities to stressors. A number of studies have found the behavior pattern to be a predictor of premature heart disease (Matthews, 1982). While there exists considerable support of the existence of such a characteristic, one recent study (Case, 1985), did not find differences between Type A's and B's. Encouragingly, there exists some evidence that Type A behavior can become unlearned (Matthews, 1982). Failure to consider these patterns would ignore "some of the better interdisciplinary research (behavioral and medical) that has been conducted in the past 25 years" (Ivanevich and Matteson, 1987, p. 223). This is not to suggest that this concept should become a driving factor in crew selection. In fact, it is speculated that the vast majority of the current astronaut core are Type A. However, full advantage should be taken to provide these highly competitive and successful people with techniques for successfully dealing with the negative consequences of the pattern.

HOT REACTORS. Elliott and Breo (1984) sought to learn why Type B individuals also have heart attacks. They focused on the physiological processes rather than simply the behavioral patterns. They suggest that "... some people experience alarm and vigilance so strongly that when they are under stress their bodies produce large amount of chemicals, which in turn cause great changes in the cardiovascular system, including remarkable rises in blood pressure" (p. 38). The authors suggest that 20% of all healthy people are hot reactors. The dangerous combination is the Type A behavior pattern with the physiological predilection for hot reacting.

HARDINESS. One of the most interesting new areas of research in moderators of stress has been that proposed and supported in a series of studies by Maddi and Kobasa (e.g., Maddi and Kobasa, 1984; Kobasa & Maddi, 1977; Kobasa, Maddi & Courington, 1981). Hardiness is purported to be a personality style that shows commitment, control, and challenge. Kobasa (1979) suggested that this factor included resilience, activeness, self-reliance, and a zest for living. She states that people with this trait work hard because they enjoy it, rather than because they feel compulsively driven. They view life as adaptable, not as a structured given. They view change as a challenge, not a disruption of how things should be. Their view suggests that stressful life events lead to strain which in turn causes various illnesses. This concept is much like the working model that has been used throughout this paper. In particular, these researchers place importance on the moderators or buffers. Their model differs in the inclusion of hardiness.

Initial validation of this concept began with the link that those with high scores in the hardiness construct actually had lower subsequent illness than others with similarly high stressful events scores (Maddi & Kobasa, 1984; Kobasa, Maddi, & Kahn, 1982). They also suggest an inverse relationship between blood pressure (suggested as a sign of strain) and hardiness.

While investigating the relationship between Type A behavior and hardiness, the researchers found no relationship (Kobasa, Maddi, & Zola, 1983), strongly suggesting that these are not identical constructs. This was important in trying to determine if these were actually separate notions. Indeed, hardiness was determined to be substantially different from other buffers including exercise (Maddi & Kobasa, 1984), social support (Kobasa & Pucetti, 1983), constitutional strength (Kobasa, Maddi, & Courington, 1981), and proper health practices (Maddi & Kobasa, 1984). In fact, hardiness was found to explain far more of the variance than any of the other variables (exercise was second).

Maddi and Kobasa further maintained that hardiness is developed. They provided a general sense of the types of things that breed hardiness. They suggest that: "The social and physical environment changes frequently, and includes many moderately difficult tasks. Parents encourage their children to construe the changes as richness and support efforts to perform the tasks successfully. More generally, the parents are warm and enthusiastic enough toward children that their interactions are usually pleasant, rewarding, and supportive of the child's individuality" (1984, p. 52). In the same work, they suggested that hardiness can be learned, to enhance stress transformation at both the individual and organizational levels.

If the moderator can be "taught", then devising strategies toward commitment rather than alienation, toward control rather than powerlessness, and toward challenge rather than threat would lead to significant stress reduction. In particular, the hardiness trait has shown to be more effective over longer periods of time than other buffers. In the face of stressors that might be present for a number of years, implications from this body of research and resultant intervention strategies merit continued monitoring.

STRESS MANAGEMENT

While not the primary emphasis of this literature review, it is perhaps useful to introduce the literature on stress management. One way of conceptualizing stress management techniques would be to categorize the myriad of methods into three major areas. These areas include: 1) treating the symptoms; 2) changing the person; and 3) removal of the stressor.

TREATMENT OF THE SYMPTOMS. Mitchell and Larson (1987) suggest that three sub-areas exist. These include medication, behavior therapy, and a number of physical techniques. Drugs have been effective in treating sleep problems, high blood pressure, anxiety, and depression. Behavior therapy focuses on treating symptoms through various reinforcement schedules. These techniques have been successful in working on anxiety, depression, social difficulties, alcoholism, etc. The physical methods include such things as massage, hot tubs, and saunas.

The reader is referred to Woolfolk and Leher (1984) for additional information.

CHANGING THE PERSON. This category involves teaching the person new skills to effect new ways of responding to stressors. Examples can be drawn from the lessons provide by the hardiness literature and detailed as a counseling strategy in Maddi and Kobasa. Many of the these techniques involve modifying the physiological reactions to stressors.

Biofeedback. This technique uses medical technology to help individuals monitor and learn to control their previously believed unmodifiable physiological responses. Fuller (1978) has shown that the person can observe the objective muscle tension, can work to change the thoughts or feelings that are related to the tension, and learn to increase the thoughts and feelings related to decreased tension. Selected references include Budzinski, 1973; Budzinski and Pepper, 1980; Stoyva, 1979.

Relaxation training. There are a number of strategies that are designed to promote relaxation. A key principle to these strategies is that one cannot be stressed and relaxed at the same time. Research supports positive effects. Refer to Bernstein and Borkovec, 1973.

Interpersonal strategies. These interventions focus on enhancing group relationships. Among the techniques are team building, sensitivity training, and assertiveness training. Selected references include Adler, Rosenfeld, and Towne, 1983; and Baron, 1985.

Physical changes. This involves actual physical changes to reduce weight, obtain exercise and increase sleep. Exercise has already been suggested as an effective method for stress reduction. However, this technique generally does not remove the stressor, but merely removes some of the pent-up feelings that are results of many of the types of stressors (Mobily, 1982). In his comprehensive review of the literature, he found that physical and recreational activities have demonstrated the potential usefulness in dealing with stress. Indeed, Sacks and Sachs (1981) refer to the benefits of jogging as a therapy. In personal interviews with experts at Florida State University's Department of Physical Education and Movement Science, they suggest that some form of exercise is critical not just for the well-established physiological needs, but for psychological needs as well. It is imperative to create substations that maintain both aerobic and anaerobic systems. One exercise that has not appeared in the literature to date would be a rowing apparatus. That exercise may have the most positive benefit-to-gain ratio. Two other considerations were mentioned. The first was that of meeting the competitive needs of the highly competitive astronaut core. A wide variety of recreational and exercise tracking strategies should be investigated and will perhaps have many crew specific differences. Finally, the experts envisioned methods to enhance the enjoyment of each to the exercise

machines. For example, technicians could devise a video monitor that would allow the crew member to "ride" through the streets of Paris, the Minnesota country side, the Colorado mountains, or explore the alleys of a small European town. These interactive video disks would change speeds depending on the rider's speed; ideally, they would permit turns that would run different real scenes. Similar routines could allow a person to row down the Mosel River in West Germany or allow the crew member to plan a four week trip down the Mississippi. Critical to their thinking are the elements of variety, interest, and intense stations that derive the most benefit in the limited space provided. Elements of competition should not be ignored.

Summary

The purpose of this paper was to present an initial limited review of the stress literature as it relates to space travel. Using Ivancevich and Matteson's model to organize selected references, dozens of potential issues were raised that may merit attention in long duration space travel. Perhaps an equally important review should focus primarily on the link between the astronauts and the entire ground support organization. Another important set of topics for review in the future would be family issues and the duration between space flights. It is during this time when many key decisions are made about continued employment; when astronauts undergo weeks of tedious training; when critical selection decisions are made; when groups of entirely different psychological make-up are forced to work closely; and when the realization sets in about the real perils of space flight and extended separation.

The section on stress management is purposefully short. It is sufficient to suggest that numerous techniques have been proven to help reduce stress, and that many professionals have the skills to help address each issue that has been mentioned in this review. It seems important that some considerable devotion of time should be given to this very topic. The thrill of adventure will not be enough to sustain our astronauts during the length of time necessary to successfully complete our longer space operations. Stress and its effects will be apparent and potentially quite costly. Efforts must be made to prevent and provide techniques for stress reduction and management.

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ANNOTATED BIBLIOGRAPHIES

ANNOTATED BIBLIOGRAPHY: VISUAL PERCEPTION

Brown, T. L. (1964). Sensory and perceptual problems in space flight. In J. D. Hardy (Ed.), Physiological problems in space exploration (pp. 209-230). Springfield, Illinois: Bannerstone House.

Discusses several problems related to human perception during spacflight including: vision, hearing, vestibular sense, and other senses.

Cameron, D. E., Levy, L., Thomas, B., & Rubenstein, L. (1961). Sensory deprivation: Effects upon the functioning human in space systems. In B. E. Flaherty (Ed.), Psychophysiological aspects of space flight (pp. 225-237). New York: Columbia University Press.

Summarizes series of experiments that investigated the behavioral results of reduced sensory input.

Carterett, E. C., & Friedman, Morton P. (1974). Handbook of Perception. New York: Academic Press Inc.

Summarizes the historical and philosophical roots of perception.

Chambers, R. M. (1964). Isolation and disorientation. In J. D. Hardy (Ed.), Physiological problems in space exploration (pp.231-297). Springfield, Ill: Bannerstone House.

Reviewed research on isolation and disorientation as it relates to problems encountered by man during space travel. This chapter attempts to identify critical problem areas, significant variables, and phenomena, and to systematize the extensive subjective data and inconsistent reports which are common in the scientific literature.

Connors, M. M., Harrison, A. A., & Akin, F. R. (1985). Living Aloft: Human Requirements for Extended Spaceflight. Washington D. C.: NASA.

Failed to find consistent perceptual changes in the weightless environment. Visual changes, if they exist, are not pronounced. However, more data emphasizing brightness, color sensitivity, dark adaptation, and accommodation, radiation and vibration are called for.

Book covered all aspects of human requirements for long duration spaceflight including: behavioral and selection implications of biomedical changes, habitability, performance, small group, communication, crises, organization and management.

Connors, M. M., Harrison, A. A., & Akins, F. R. (1986). Psychology and the resurgent space program. American Psychologist, 41, 906-913.

The article reviews how psychological principles can impact on the space program. Addressed are many psychological issues including biobehavioral aspects, human factors aspects, communications, and personal and social adjustment. The authors also bring up many issues concerning the roles that psychologists can play in influencing the space program.

Department of Behavioral Sciences and Leadership, USAF Academy. (1984). Psychological, sociological, and habitability issues of long duration space missions. NASA TR T-1082K. Houston, TX: National Aeronautics and Space Administration.

Surveyed the research literature surrounding the following three topics: Space station habitability, the impact of biological rhythms, and the influence of group dynamics. The impact of these areas on human behavior in the long duration space mission were discussed.

Egan, J.P., Greenberg, G. Z., & Schulman, A. I. (1961). Interval of time uncertainty in auditory detection. Journal of the Acoustical Society of America, 33, 771-778.

Investigated the detectability of an auditory signal when the signal is very weak and brief and when it is embedded in a noise that lasts a few seconds. Explanation in terms of short term memory and vigilance performance are also discussed.

Genco, L. V., & Task, H. L. (1984). Testing changes in visual function due to orbital environment. (AFAMRL-TR-84-049). Wright-Patterson AFB, OH: Air Force Aerospace Medical Research Laboratory.

Describes the visual function tester model 1 (VFT-1). In response to NASA and anecdotal evidence of vision changes in orbit, the VFT-1 was designed to test several human vision parameters and indicate which may have occurred due to the effects of orbital flight. Describes VFT-2 and VFT-3 functions, however; no actual data from orbital subjects were reported.

Grether, W. F. (1965). Visual search in the space environment. In C. A. Baker (Ed.), Visual capabilities in the space environment (pp29-36). New York: Pergamon Press.

Discusses the importance of vehicle search for other vehicles in a coplanar orbit for purposes of rendezvous. An example is provided to illustrate the method of computing the probability of sighting.

Hoffman, R. A., Pinsky, L. S. Osborne, W. Z., & Baily, V. J. (1977). Visual light flash observation on Skylab 4. In R. S. Johnston and L. F. Dietlien (Eds.), Biomedical Results from Skylab (pp127-130). Washington D. C.: NASA.

Reported on the observation of light flashes possibly due to heavy atomic particles first reported by Apollo crewmembers. The observer must be relaxed and the eye must be dark adapted in order to observe the phenomenon. Questions whether permanent damage to either the retinal cells of the eye or neurons in the brain occur. Suggests additional research is needed.

Hyman, A. (1965). Utilizing the visual environment in space. In C. A. Baker (Ed.), Visual Capabilities in the space environment (pp. 1-12). New York: Pergamon Press.

Several procedures for dealing with distance estimation are analyzed. The procedures include using angular subtense and luminance and illuminance factors.

Jerison, H. J., & Pickett, R. M. (1965). Vigilance : A review and re-evaluation. In C. A. Baker (Ed.), Visual capabilities in the space environment (pp.37-64). New York: Pergamon Press.

The whole vigilance area is reexamined with the help of a theoretical model that introduces a decision theory approach to the observing phase of the vigilance task. After a critical review of the vigilance literature, examples are presented of the application of this approach to solving human factors problems during manned space missions.

Johnston, R. S., & Dietlein, L. F. (Eds.) (1977). Biomedical results from Skylab. NASA SP-377. Washington, D. C.: Scientific & Technical Information Office.

Describes the skylab project. Presents experimental results in neurophysiology, musculoskeletal function, biochemistry, hematology, cytology, cardiovascular, and metabolic function.

Miller, J. G. (1961) Sensory overloading. In B. E. Flaherty (Ed.), Psychophysiological aspects of space flight (pp. 215-224). New York: Columbia University Press.

Discusses the known effects of sensory overload and the process of adjustment used by humans to compensate for unusually high information input rates.

National Academy of Sciences (1972). Human Factors in Long-Duration Spaceflight. Washington D. C.: Space Science Board, National Academy of Sciences.

Covers early research (prior to 1972) regarding human physiological, physical, and sensory requirements for long duration spaceflight. Most conclusions are based on extrapolation of research in areas such as isolation and confinement. Topics covered include: physiological and medical factors; physical factors; sensory, perceptual, and motor factors; motivation, cognition, and sleep-wake factors; skilled performance; subjective state; group processes and interpersonal interaction; a social system approach to long-duration missions; and human factors and operational requirements.

Pigg, L. D., & Kama, W. N. (1961). The effect of transient weightlessness on visual acuity. WADC Tech. Rep. 61-184, Wright-Patterson AFB, Ohio: Wright Air Development Center.

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Pitts, J. A. (1985). The Human Factors: Biomedicine in the Manned Space Program to 1980. Washington D. C.: NASA.

An historical review of NASA's biomedicine program through the 1980's. Discusses the fiscal, political, and scientific concerns of implementing a manned space flight program. Presents results of biomedical experiments conducted during the Mercury, Gemini, and Appollo programs.

Simons, D. G., Henderson, B. W., & Riehl, J. L. (1961). Personal experiences in space equivalent flight. In B. E. Flaherty (Ed.), Psychophysiological aspects of space flight (pp.39-49). New York: Columbia University Press.

This paper, from a psychophysiological point of view, relates three personal experiences related to space flight. Many of the similarities and differences among them are identified, and the neurophysiological implications of several of the most impressive phenomena are discussed.

Skylab: Lessons Learned (1974). (NASA-TM-X-64860). Washington D. C.: National Aeronautics & Space Administration.

Provided primarily anecdotal data on crew preferences and recommendations related to equipment design.

Swets, J. A., Tanner, W. P., Jr., & Birdsall, T. G. (1961). Decision processes in perception. Psychological Review, 68, 301-340.

Reviews the theory of statistical decision and presents a description of the elements of the theory of signal detection appropriate to human observers. The results of some experimental tests of the applicability of the theory to the detection of visual signals are described.

Yakovleva, I. A., Kornilova, L. N., Tarasov, I. K., & Alesheev, V. N. (1982). Studies of the vestibular and spatial function in Cosmonauts. Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina, 16(1), 20-26. (From Psychological Abstracts, 1983, 69, Abstract No. 7508)

Discusses the results of studying 26 cosmonauts' vestibular and spatial perception functions. Discusses five typical postflight changes: (1) increase in reactivity of the otolith organ, (2) decrease sensitivity of semicircular canals, (3) decline in perception of spatial coordination accuracy, (4) asymmetry of most parameters, and (5) development of illusionary reactions in flight.

Zink, D. L. (1965). Visual experiences of the astronauts and cosmonauts. In C. A. Baker (Ed.), Visual capabilities in the space environment (pp. 13-27). New York: Pergamon Press.

The major visual experiences of the astronauts and cosmonauts are described and compared with predictions of man's capabilities made prior to actual space flight. Most of the data are anecdotal in nature and more careful experimentation is needed.

ANNOTATED BIBLIOGRAPHY : RHYTHMIC INFLUENCES

Aschoff, J. (1978). Features of circadian rhythms relevant for the design of shift schedules. Ergonomics, 21 (10), 739-754.

A review of numerous investigations by the author leads to several conclusions. For example, when isolated in soundproof chambers and deprived of the usual timing references, the circadian rhythms in humans will not follow their usual 24-hour periodicity but will increase to longer periods, even though they will remain quite stable and predictable in these longer periods. Although the most important timing reference for most animals is the light/dark cycle, for humans, social cues (meal timing, work hours, etc.) seem to be the most important time giver (Zeitgeber). This is not to say that the light/dark cycle is not important--it is simply not the most important. It is pointed out that shift workers constantly suffer from dysrhythmia since their Zeitgebers are being shifted so often, and how quickly these shift workers adjust to their new shifts depends in part on the direction of the shift in hours. In general, it takes longer to adjust to a delayed shift (one which progresses from day to evening to night shifts) than an advanced one which starts with night shifts and ends with day shifts.

Borowsky, M. S., and Wall, R. (1983). Naval aviation mishaps and fatigue. Aviation, Space, and Environmental Medicine, 54 (6), 535-538.

The purpose of the study was to determine if aircraft accident liability and physical and/or mental fatigue were somehow correlated. Only class A accidents (those involving permanent disabilities or \$500,000 of property damages) were studied. Factors considered in each mishap included work hours in the preceding 24/48 hours, missions flown in that time period, continuous hours without sleep prior to accidents, hours of duty prior to the mishap, length of the last sleep period, amount of sleep in the preceding 48 hours, and the number hours flown in the 48 hours preceding the mishap. Results indicated that liability in naval aircraft mishaps is reliably related to the number of hours worked in the preceding 24 hours, but that none of the other factors mentioned above is correlated with accident liability. These results are discussed as supporting a circadian desynchronization hypothesis.

Bossom, J., Natelson, B.H., Levin, B.E., and Stokes, P.E. (1983). Ultradian rhythms in cognitive functions and their relationship to visceral processes. Physiology and Behavior, 31, 119-123.

The purpose of this study was to search for certain ultradian rhythms in human cognitive functions. Specifically, these investigators used commercially available games to study non-verbal recall (short-term memory) and eye-hand coordination (visuo-motor coordination and attention) in seven normal adult males. The results indicate that there are specific ultradian rhythms in visuo-motor performance and recall as well. The period for both rhythms seems to be approximately 90 minutes. These results indicate, however, that there may be no predictive relationship between the two rhythms. Neither rhythm, in addition, correlated with the excretion of catecholamines, and these authors conclude that the relationship between biological and behavioral functions might be more effectively studied over longer periods of time.

Buck, L. (1980). Circadian rhythms of performance among workers in the arctic. Aviation, Space, and Environmental Medicine, 51 (8), 805-808.

In an attempt to separate solar zeitgebers (sunrise and sunset) from social cues (work times, meal times, social hours, etc.), performance on a standardized test was studied in 21 subjects who worked at Resolute Bay in the Northwest Territories of Canada. In this area, the sun neither rises nor sets between early November and early February, nor does it set at all between late April and mid August. Therefore, there are four periods for study: one in which the sun is always present; one in which the sun is consistently absent; and two transition periods during which there are both sunrises and sunsets. Previously it had been determined that performance on the standardized pursuit tracking task was known to vary with the time of day, with performance slow and accurate early in the day and becoming faster but less accurate as the day progressed. In this study it was hypothesized that these known circadian variations in performance would be most pronounced following the transition periods and not as prominent following the periods free of sunrise and/or sunset. The results disproved the original hypothesis, however, with there being no reliable change in circadian rhythm of performance even when solar light/dark cycles were absent.

Colquhoun, W. P. (1984). Effects of personality on body temperature and mental efficiency following transmeridian flight. Aviation, Space, and Environmental Medicine, 55, 493-496.

This study examined whether the observed physiological disruption in circadian rhythms following phase shifts could be predicted based on the personality type of the subjects. Thirty-eight males categorized as either introverts, extroverts, stable, or neurotic by the Eysenck Personality Inventory served as subjects for this study. Subjects were passengers of a flight lasting 21 hours and crossing 8 time zones, and their body temperature was observed for 10 days following this flight. Mental performance, in addition, was measured with arithmetic tests. An elevation of the body temperature rhythm was found in all subjects and lasted ten days. There was a corresponding loss in mental agility following the flight, and this study stated that this loss in mental efficiency was related to the disruption of the physiological circadian rhythm. The amount of disruption could be reliably predicted before any disruption occurred by use of appropriate personality tests. The disruption in both physiological and mental performance rhythms will be greatest for introverts as compared to extroverts, and this difference will be accentuated in neurotic subjects, as determined by the Heron Personality Inventory.

Colquhoun, W. P. (1985). Hours of work at sea: Watchkeeping schedules, circadian rhythms, and efficiency. Ergonomics, 28 (4), 637-653.

This report is essentially a review of the works of the author and other experimentors interested in the degree of adjustment in physiological and performance rhythms when subjects are exposed to various hours of work; i.e., shift work. This review looks at three types of systems: a stabilized system; a rotating system; and non-24 hour routines. The conclusions from the studies

of these three systems are that rotating shifts have few, if any, benefits to recommend them since it is almost impossible to adjust to them and that dysrhythmia may occur. Stabilized systems produce fewer problems than the other two, and, therefore, should be used on ocean-going vessels until further research can be conducted.

Connors, M. M., Harrison, A. A., and Akins, F. R. (1986). Psychology and the resurgent space program. American Psychologist, 41 (8), 906-913.

The purpose of the review was to consider some trends in spaceflight that may have important behavioral implications for human crews. The authors assert that the space program is in a transitional state, moving from an era of simple exploration and visitation to one in which humans will actually live in space for extended periods of time. Psychological areas considered in this review include biobehavioral issues (adaptation to lack of gravity, gender differences, age considerations, exercise, space adaptation syndrome. etc), human factors issues (food, odors, tactile stimulation, design of work stations, scheduling of work and rest, and recreational considerations), communications (interpersonal, between crew and the earth, etc), and personal and social adjustment issues (social adjustment, crew selection, personal crises, stress, etc).

Craig, A., Wilkinson, R.T., and Colquhoun, W.P. (1981). Diurnal variation in vigilance efficiency. Ergonomics, 24 (8), 641-651.

This study presented the results of five different experiments all concerned with how human performance on auditory vigilance tasks varied throughout the normal waking day. For each of these studies, young men enlisted in the British Navy served as subjects, and their performance on differing auditory tasks was measured either four or five times during their normal waking day. Only one of these experiments was confined to normal working times. Results from these five experiments indicate that there is a time of day effect on auditory vigilance tasks. This observed effect is less pronounced during the normal working day as opposed to the more extended waking day. The general conclusion of the paper is that hits and false alarms on vigilance tasks are effected in parallel, both tending to be lowest at the start of the waking day and increasing only slightly as the day progresses.

Czeisler, C. A., Moore-Ede, M.C., and Coleman, R. M. (1982). Rotating shift work schedules that disrupt sleep are improved by applying circadian principles. Science, 217 460-463.

The purpose of this study was to seek to determine which schedules of work would decrease worker dissatisfaction with shift work schedules. The argument presented is that workers suffer from dissatisfaction with work, poor health, decrements in productivity, sleep/wake problems, and personnel turnover because the shifts they are required to work interfere with the normal human circadian rhythms. Most shift work today involves phase advancing (from nights, to evenings, to day shift), and most rotate rapidly, with only seven days per shift. In this experiment, two groups of workers were given differing shifts, and after nine months, various measures of performance and satisfaction (both objective and subjective) were obtained. One group continued with a normal shift (phase advancing, seven day rotation) while the experimental group was given a phase-delay schedule with 21-days between rotations. Results indicate that the slow rotating, phase-delay schedule was more favored by workers, resulted in improvements in workers' health index and also showed a reduction in personnel turnover.

Folkard, S., Knauth, P., Monk, T. H., and Rutenfranz, J. (1976). The effect of memory load on the circadian variation in performance efficiency under a rapidly rotating shift system. Ergonomics, 19 (4), 479-488.

It has long been thought that there is a parallel between the circadian rhythms of temperature and performance. That is, as the body temperature rises, so does one's performance on psychomotor skills and mental tasks as well. However, the investigators point out that many studies in this area have diverse results and that performance may in fact be either inversely related to temperature, may show no relation whatsoever, or may closely parallel temperature, depending on how the particular task being studied involves memory storage. This study involved a measure which could be varied with respect to the amount of memory required to successfully accomplish the task. These investigators found that with low memory-loaded tasks, performance is positively correlated with temperature. However, when the task was a highly memory-loaded version, performance was negatively correlated with temperature. Further investigation is required in this area, but it seems true that there can be no simple relationship between body temperature and performance unless the memory load of the task to be studied is well understood.

Folkard, S., and Monk, T. H. (1979). Shiftwork and performance. Human Factors, 21 (4), 483-492.

This study reviewed the current literature concerned with performance on and adjustment to changes in working hours. Specifically, it was suggested that as technology advances, the cognitive requirements of workers is becoming more and more demanding, and that this increase in cognitive load must be considered when studying shift work performance. The authors offer a model in which on-shift performance is dependent on the type of task, the type of person, and the type of shift system, with all three variables interacting with the workers' circadian rhythms. The authors point out that whereas a few years ago task demands were considered as consistent across all situations, today this is recognized as not the case. For example, performance on a task which has a low memory storage requirement will probably parallel that of body temperature, while performance on a task which is highly cognitively loaded would be negatively correlated with temperature. The amount of time required for performance on different cognitively loaded tasks to adjust to changes in work hours also varies. In addition, there are significant individual differences in the degree to which circadian rhythms adjust to shift work. Extroverts seem to be less affected by shift work changes, and evening types (measured by Horne and Ostberg, 1976) adjust easier also. All three of these variables must be considered when studying performance on shift work.

Folkard, S., and Monk, T. H. (1980). Circadian rhythms in human memory. British Journal of Psychology, 71, 295-307.

This study, which consisted of two experiments, was concerned with the time of day effects of the presentation of material on immediate and delayed recall and the time of day effects on retrieval of information from long term memory. In the first experiment, 36 undergraduates served as subjects who were tested at six different times each day for two days. Experimenters found that immediate memory shows an almost mirror image to that of oral temperature rhythm.

That is, immediate memory appears highest early in the waking day and shows a steady decline thereafter. In the second experiment, 50 female nurses served as subjects who were divided into two groups. One group contained full-time night workers, and the other group was composed of part-time night workers. All were shown a film and given a questionnaire 28 days later. Results indicated that those who had not adjusted well to shift hours performed their immediate memory task best at 0400 rather than at 2030, but those who had adjusted to the shift had the opposite results.

Folkard, S., and Monk, T. H. (1983). Chronopsychology: Circadian rhythms and human performance. In A. Gale & J. A. Edwards (Ed.), Physiological correlates of human behavior: Vol. II Attention and performance (pp 57-78). London: Academic Press.

This review of the literature explains differing approaches to the study of physiological rhythms and circadian rhythms of performance, and it concludes with a theory to explain the differences between various performance rhythms. They provide evidence from studies which lends support to the proposition that indeed circadian rhythms in various performance measures are controlled by more than one oscillator. The authors also suggest that performance on memory-loaded cognitive tasks may be under the control of an oscillator which is entirely different than the oscillator that controls the sleep-wake cycle or the body temperature cycle. The investigators also provide evidence to support the claim that changes in performance over the working day are typically in the range of 10%, which equates to the decrement from the ingestion of a legal dose of alcohol. Also supported in this article is the claim that while speed on various tasks increases over the waking day, accuracy scores actually decline. Finally, the authors presented their "multi-oscillator" theory which purports to explain some of the misunderstandings in the field of chronopsychology.

Folkard, S., Wever, R. A., & Wildgruber, C. M. (1983). Multi-oscillatory control of circadian rhythms in human performance. Nature, 305, 223-226.

In an attempt to determine whether there are at least two types of endogenous oscillators (those which control the body temperature rhythm and are relatively immune to exogenous factors and others which influence the sleep/wake cycle and are more susceptible to environmental fluctuations) these investigators employed Wever's fractional desynchronization technique. This experimental technique exposes laboratory subjects to artificial zeitgebers (incorrect clocks, differing meal times, light/dark cycles, work hours, etc) and results in systematically lengthening or shortening successive "days" without the subjects' knowledge. Three subjects experienced shortened days while the remaining four experienced days which were actually longer than 24 hours. It is hypothesized that under such conditions certain rhythms should separate. Two performance tests were used. One was a simple letter cancellation test while the other was more cognitively demanding. Normally, performance on these tests can be estimated: performance on the more cognitively loaded task reaches a peak around noon, while performance on simple letter cancellation tasks peaks later in the waking day. Results showed that in all subjects, performance on the letter cancelling task paralleled the subjects' temperature rhythm. However, three subjects exhibited separation of their verbal reasoning rhythm from either the body temperature rhythm or the letter cancellation rhythm.

This verbal reasoning rhythm lasted about 21 hours. The experimentors concluded that performance on similar tasks which requires little memory is controlled by the same oscillator which is responsible for body temperature. In contrast, memory loaded performance rhythms are controlled by a different oscillator which is 21 hours in duration.

Folkard, S., Hume, K. L., Minors, D.S., Waterhouse, J.M., and Watson, F. L. (1985). Independence of the circadian rhythm in alertness from the sleep/wake cycle. Nature, 313, 678-679.

The purpose of this study was to determine if human diurnal feelings of alertness or drowsiness was indeed correlated with the sleep/wake cycle or if this rhythm was dependent on the same endogenous circadian oscillator used to account for the circadian rhythm of body temperature. Twelve students served as subjects and all were isolated in special housing units away from normal zeitgebers (light/dark cues, radios, TVs, clocks, social engagements, etc.) for a period of 21 days. Artificial zeitgebers were introduced until a complete "day" for these subjects was reduced to 22 hours. Body temperature was measured throughout the study and subjective measures of alertness and drowsiness were collected from each subject every two hours and forty minutes. Results indicated that the sleep/wake cycle was more influential in the regulation of body temperature than it is in the circadian rhythm of alertness. It is possible, therefore, for the circadian rhythm of alertness to become independent of the sleep/wake cycle.

Jamal, M. (1981). Shift work related to job attitudes, social participation, and withdrawal behavior: A study of nurses and industrial workers. Personnel Psychology, 34, 535-547.

Nurses and workers in a manufacturing organization served as subjects for this experiment which sought to determine the relationship between differing shift schedules and job satisfaction, organizational commitment, turnover, rate of absenteeism, tardiness, and mental health. Data were gathered via questionnaires from all subjects. Results from questionnaires indicated that workers on fixed shifts enjoyed a higher level of mental and emotional health, organizational commitment, and turnover intention than did subjects from either group who worked on a rotating shift system, even though these latter two groups were representative of two entirely different work settings. These findings are in agreement with other studies which conclude that workers assigned to rotating shifts suffer more health problems than do those workers who work on permanent day, evening, or night shifts.

Jamal, M., and Jamal, S. M. (1982). Work and nonwork experiences of employees on fixed and rotating shifts: An empirical assessment. Journal of Vocational Behavior, 20 283-293.

This study sought to determine the relationship between hours of shift work and job performance, nonwork satisfaction, mental and physical health, and use of leisure time of workers in hospitals and manufacturing environments. Data were collected from subjects using questionnaires. Among other considerations, it was hypothesized that individuals working on fixed shifts would perform more efficiently on the job, would spend a larger percentage of their leisure time with their families and friends and would generally be more satisfied with both on- and off-work activities than individuals scheduled to work on rotating shifts.

The results indicated that workers on fixed shifts did indeed suffer from fewer physical health and psychological depression problems than did those on rotating schedules. However, no reliable differences in job performance between the two groups were found to exist.

Latman, N. S., and Garriott, J. C. (1980). An analysis of biorhythms and their influence on motor vehicle fatalities. Accident Analysis and Prevention, 12 (4), 283-286.

The purpose of this experiment was to resolve some of the contradictions surrounding the effectiveness of biorhythms in determining human behavior. Biorhythms supposedly consist of three different cycles which can affect human behavior. One of these cycles relates to a peak in emotional sensitivity (28 days), one to intelligence peaks (33 days), and the final cycle supposedly controls physical prowess (23 days). This study investigated 141 motor vehicle fatalities and found no reliable correlation between the victims' peaks or troughs in their biorhythms and their involvement in an accident. This study provides further evidence that biorhythms, in and of themselves, are not a reliable predictor of behavior or performance.

Matthews, M. D. (1985). Circadian rhythms and long duration space flight. In Psychological, sociological, and habitability issues of long-duration space missions. (Report #T-1082K) Johnson Space Center, Houston, TX: NASA.

This review analyzes studies from environments similar to those likely to be encountered on long-duration space missions. Reviewed were findings from submarines, exploration parties, prisons, and remote tours of duty. The author discusses circadian rhythms and their effect on performance, sleep, and deprivation of sleep and resultant performance decrements and various work/rest cycles and performance on a variety of tasks. Conclusion are drawn from these studies and several are offered which could optimize performance and help enhance personal and social adjustment to long duration space mission environments.

Minors, D.S., and Waterhouse, J.M. (1983). Circadian rhythm amplitude-is it related to rhythm adjustment and/or worker motivation? Ergonomics, 26(3), 229-241.

This article presents the results of two studies, both of which are concerned with the ability or inability of certain workers to adjust physically and psychologically to working at differing times of the day, either on rotating or nonrotating shifts. They point out that the personality of the worker, the amplitude of the worker's circadian rhythms, and the phasing of his/her rhythms have all been previously identified as variables in determining which workers will be more tolerant of night work. Typically, workers who possess circadian rhythms of larger amplitudes than those of their colleagues tend to be more tolerant of night work. In addition, personality is generally accepted as a determinant of successful adaptation to changing schedules. Those who display an inflexibility of sleeping habits and who become extremely agitated at being awakened while attempting to sleep tend to be the ones who cannot adjust to shift schedules. The two new studies presented here were concerned with providing further evidence to the existing data on this topic.

One experiment studied subjects in an isolation unit, while the other study looked at a group of nurses whose times of sleep and activity during both night shifts and free days were recorded. Results indicate that circadian rhythms of high amplitude might be a consequence of regular sleep-wakefulness cycles, and not a predictive variable which reliably determines which workers would be successful as shift workers.

Monk, T. H., Weitzman, E. D., Fookson, J. E., and Moline, M. L. (1984). Circadian rhythms in human performance efficiency under free-running conditions. Chronobiologia, 11, 343-353.

A series of four experiments was conducted in this investigation which sought to determine if performance on several different tasks varied rhythmically. These investigators also sought to determine which oscillators controlled these various rhythms. Performance on three different tasks was measured: manual dexterity, serial search, and complex verbal reasoning. All subjects were housed in special isolation units where normal zeitgebers (light/dark cycles, clocks, TVs, radios, etc.) were absent. Results indicate that there are predictable circadian characteristics for various tasks and that the rhythms for simple repetitive tasks such as manual dexterity and serial search are under the control of an oscillator entirely different than the oscillator controlling complex verbal reasoning. In general, the rhythm of complex verbal reasoning shows a shorter period than the rhythm for simpler tasks.

Monk, T. H., and Leng, V. C. (1982). Time of day effects in simple repetitive tasks: Some possible mechanisms. Acta Psychologica, 51, 207-221.

After a brief review of the literature concerned with diurnal rhythms (time of days effects), performance and arousal, three experiments are presented which attempted to determine if performance on simple repetitive tasks and the time of day when they were performed were correlated. Results indicated that over the waking day there is a tendency for people to perform simple, repetitive tasks quicker but less accurately as the day progresses. The authors point out that these results can not be explained by the speed of information processing but rather that these changes in performance are mediated by the amount of information processed.

Moore-Ede, M. C., and Richardson, G. S. (1985). Medical implications of shift-work. Annual Review of Medicine, 36, 607-617.

This study relates the changing technological and economic environment of our present culture to the consequent performance of individuals required to work at various times of the day and night to keep pace with these advances. Problems of adjustment in shift workers are also discussed - sleep/wake disorders, gastrointestinal disorders, and cardiovascular disorders. The authors also present evidence that there are significant individual differences in the ability to adapt to rotating shift work schedules. Individuals who suffer from abrupt changes in schedules may develop "Shift Maladaptation Syndrome." It may be possible to determine those individuals who would suffer the consequences of Shift Maladaptation Syndrome, as they would normally exhibit a low amplitude body temperature rhythm.

Reinberg, A., Andlauer, P., Guillet, P., Nicolai, A., Vieux, N., and LaPorte, A. (1980). Oral temperature, circadian rhythm amplitude, aging, and tolerance to shift work. Ergonomics, 23 (1), 55-64.

The purpose of this experiment was to determine possible correlations between the circadian rhythm of body temperature to a worker's tolerance to shift work and the speed of this worker's adjustment to changing schedules. Shell Oil refinery operators voluntarily served as subjects and were separated into four groups: group 1 was comprised of healthy, young men; group 2 contained older men (50 years old average) with no health problems; group 3 had older men with only minor medical problems; and group 4 was comprised of older men with major medical problems. In this study, intolerance to shift work was operationally defined as when workers complained of either gastritis and peptic ulcers, persisting fatigue, or sleep alterations, or any combination of the three. Results indicated subjects who are tolerant to shift work over many years are likely to have a large amplitude in circadian temperature rhythms (measured as amount of change), and that these workers will probably adjust slowly to new schedules. These experimenters conclude that rapidly rotating shifts should be preferred to slower rotating ones and that circadian rhythm amplitudes should be a reliable index of long-term tolerance to shift work.

Takahashi, J. S., and Zatz, M. (1982). Regulation of circadian rhythmicity. Science, 217, 1104-1110.

The purpose of this study was to explore the underlying physiological mechanisms responsible for the circadian rhythm in humans and other mammals. The authors divide their presentation into three subsections: the first describes certain properties of circadian rhythms; the second describes the anatomical basis of circadian systems; and the third summarizes model systems for biochemical analysis. Evidence presented in the study points to the mammalian suprachiasmatic nucleus, the avian pineal gland, and the aplysia eyes as the regulators of circadian rhythmicity. Although there has been little disagreement concerning the role of these anatomical structures in the regulation of circadian rhythms, there are serious problems in the exact identification of the biochemical components involved. Cyclic AMP (adenosine 3',5'-monophosphate) has been implicated as well as serotonin, but the exact process is still under investigation.

Ward, R.E., and Stobbe, T.J. (1984). Scheduling of shiftwork in industry: The human factor. Industrial Management, 26 (4), 22-25.

The purpose of this study was to highlight some of the problems encountered by production planners and shift work schedulers in industry in the task of scheduling workers to meet demands and the possible effects of shift work on worker health and industrial production. The authors describe as consequences of shift work disruptions to family life, weariness, irritability, depression, disinclination for work, sleep disturbances, appetite and digestive troubles, coronary disease, and lowered quantity and quality of production. As a result of an extensive ten-year industrial experiment, they report that health indices, sleep/wake preferences, and schedule preferences of the workers effected by this experiment all show marked benefits from a 21-day schedule over that of a 7-day schedule. That is to say that on the experimental shift, workers rotated once every 21 days while on the control shift they rotated once every 7 days.

In addition, the experimental schedule offered a phase delay in which shifts rotated from the morning first, then to the afternoon, and finally to the night shift, as opposed to the typical phase advanced schedule which changes in the opposite direction. Worker productivity was shown to have increased significantly as a result of the new schedule, and many other subjective indices from workers increased as well.

Watts, B. L. (1982). Individual differences in circadian activity rhythms and their effects on roommate relationships. Journal of Personality, 50 (3), 374-384.

The purpose of this study was to investigate the psychological correlates of individual differences in circadian activity rhythms. Subjects were college students who were divided into either morning or evening types according to the Horne and Osterberg (1976) Morningness-Eveningness Questionnaire. Later, these subjects were interviewed and asked to complete a questionnaire concerning their relationship with their roommates. Results indicated that those who were determined to be morning-active were also more sensitive to time-urgency items and achievement than were evening-active types. In addition, those morning-active subjects who had evening-active roommates described their relationship with their roommate as poor. Subjective responses ranged from not getting along well to not wanting to continue living together, etc. These results were discussed in terms of the importance of individual differences in rhythms to psychological and social situations and to understanding interpersonal relationships from a circadian rhythm perspective.

Winget, C. M., DeRosia, C. W., Markley, C. L., and Holley, D. C. (1984). A review of human physiological and performance changes associated with desynchronization of biological rhythms. Aviation, Space, and Environmental Medicine, 55, 1085-1096.

This review of the literature focuses its attention on the physiological and psychological consequences of the disruption of normal human circadian rhythms (dysrhythmia) and how this dysrhythmic state could affect aerospace operations. Although dysrhythmia may manifest itself in irritability, digestive problems, sleep/wake abnormalities, and in decrements in physical and mental efficiency, in and of itself it is not considered life-threatening. Evidence is presented which indicates that individuals with smaller amplitudes in the circadian rhythm of body temperature will show fewer problems with adapting to new working hours. According to these investigators, Soviet scientists have developed procedures whereby an individual's rhythm stability can be measured. The Soviets conclude that those individuals whose circadian rhythms are less stationary would have fewer difficulties adjusting to the unusual sleep-wake schedule and should, therefore, be selected to serve in space missions. Several therapies for dealing with dysrhythmia are identified, including drug administration, exercise, pre-adaptation, relaxation techniques, and altered meal-timing and dietary constituents.

Winstead, D. K., Schwartz, B. D., Mallott, D., and Bertrand, W. E. (1984). Biorhythms revisited: Rhythm and blues? Journal of Clinical Psychiatry, 45, 426-429.

The investigators in this study sought to determine whether there is a consistent, reliable relationship between the date of a psychiatric admission and the biorhythm of the person being admitted. Biorhythm is the term given to the supposedly 23-day physical, 28-day emotional or sensitivity cycle, and a 33-day intellectual cycle. Supposedly these rhythms can be represented by sine waves, with the ascendent period being favorable and the minus period representing a time of reduced functioning. The hypothesis tested in this study was that when biorhythms are in a critical period, a patient is more likely to be admitted to a hospital. Hospital patients served as subjects: 192 suffered from depression; 88 from bipolar disorders; and 33 with schizophrenia. Results indicated that there is no significant relationship between admission date and the biorhythms of the admittee. These results lend further support to the findings that biorhythms have no foundation in fact.

ANNOTATED REFERENCES: MEMORY

- Baddeley, A. D., Hatter J. E., Scott D., & Snashall, A. (1970). Memory and time of day. Quarterly Journal of Experimental Psychology, 22, 605-609. This is a very early study of effects of time of day on memory. Immediate memory was found to be better in the morning than in the afternoon. Provides references for other early studies of effects of circadian rhythms on human performance.
- Bahrack, H. P. (1984). Semantic memory content in permastore: Fifty years of memory for Spanish learned in school. Journal of Experimental Psychology: General, 113, 1-29. This is a lengthy description of the author's concept of a type of memory he calls "permastore." The effects of circadian disruption on permastore have not been examined, but future researchers may want to look at this.
- Bosson, J. P., Natelson, B. H., Levin B. E., & Stokes, P. E. (1983). Ultradian rhythms in cognitive functions and their relationship to visceral processes. Physiology and Behavior, 31, 119-123. The existence of ultradian rhythms, or those of less than 24 hours in duration, is shown here. The data also indicate that considerable variation exists in normal ultradian rhythms, and presumably these may be disrupted in the orbital environment.
- Derrick, W. L. (1985). Report overview. In Psychological, sociological, and habitability issues of long-duration space missions. NASA TR T-1082K. Houston: National Aeronautics and Space Administration, Lyndon B. Johnson Space Center. Derrick's paper is an introduction to a technical report examining a variety of behavioral/social sciences aspects of human performance in space. This is a very good overview of many methodological/procedural problems encountered in work of this type.
- Folkard, S. (1979). Changes in immediate memory strategy under induced muscle tension and with time of day. Quarterly Journal of Experimental Psychology, 31, 621-633. Folkard again shows superiority of immediate memory in the morning, but also shows that instructions on how to encode or store information may ameliorate this effect.
- Folkard, S., Monk, T. H., Bradbury, R., & Rosenthal, J. (1977). Time of day effects in school children's immediate and delayed recall of meaningful material. British Journal of Psychology, 68, 45-50. In general, earlier reports of enhanced STM in the morning and better LTM later in the day are replicated, this time on a sample of school children.
- Folkard, S., & Monk, T. H. (1980). Circadian rhythms in human memory. British Journal of Psychology, 71, 295-307. Reporting on the results of two experiments, the authors indicate that immediate memory (STM) for information in prose or other "naturalistic" contexts changes by 15% over the waking day, and that the time of day at which material is presented seems to have a sizable effect on the delayed retention of the material.

- Hockey, G. R. J., Davies, S., & Gray, M. M. (1972). Forgetting as a function of sleep at different times of day. Quarterly Journal of Experimental Psychology, 24, 386-393. Using tests of verbal recall, the authors found that time of day is a more important variable than sleep vs. non-sleep. Due to problems with the experimental design, however, conclusions must be tentative.
- Kanus, N. A., & Feddersen, W. E. (1971). Behavioral, psychiatric, and sociological problems of long duration space missions (Report No. TM X-58067). Houston: National Aeronautics and Space Administration. This is the original technical report sponsored by NASA that Derrick and his associates updated in 1985.
- Kleitman, N. (1963). Sleep and wakefulness. Chicago: The University of Chicago Press. One of the original works on the effects of circadian rhythms, Kleitman's work investigates body temperature as a correlate of cognitive functioning. The basis for much of the work in this area over the past twenty years.
- Matthews, M. D. (1985). Circadian rhythms and long duration space flight. In Psychological, Sociological, and Habitability Issues of Long-Duration Space Missions. NASA TR # T-1082K. Houston: National Aeronautics and Space Administration. A comprehensive review of the general effects of circadian disruption on human performance, social behavior and adaptability is provided. Some recommendations for reducing these effects are presented.
- McCloy, T. M. (1985). Ergonomic issues of space station crew habitability. In Psychological, sociological, and habitability issues of long-duration space missions. NASA TR # T-1082K. Houston: National Aeronautics and Space Administration. Ergonomic factors involved in space station habitability are reviewed. Topics covered include clothing, work station design, internal environment, and operator variables.
- Naitoh, P., Beare, A. N., Biersner, R. J., & Englund, C. E. (1981). Altered circadian periodicities in oral temperature and mood in men on an 18-hour work-rest cycle during a nuclear submarine patrol. (NHRC Report No. 81-1). San Diego, CA: US Naval Health Research Center. This report is of special interest because the research was conducted in an environment that maintains many similarities to space in terms of confinement, altered environmental cues, and crowding.
- Naitoh, P., Englund, C. E., & Ryman, D. H. (1982). Restorative power of naps in designing continuous work schedules. Journal of Human Ergology, 11, 259-278. A good review of the effects of napping on task performance. Provides many additional references in this area.
- Spear, N. E. (1978). The processing of memories: Forgetting and retention. Hillsdale, N. J.: Lawrence Erlbaum Associates. For someone not well versed in the psychology of memory, this book provides a thorough review. Many of the variables treated here have not been examined in analogue environments or under conditions of altered cues; thus, many possibilities for future research are implied.

Tilley, A., & Warren, P. Retrieval from semantic memory at different times of day. Journal of Experimental Psychology: Learning, Memory, and Cognition, 9, 718-724. Experimenters report that retrieval from memory (LTM) is least efficient early in the day, and improves as the day progresses, when studying semantic memory stores.

Wickens, C. D. (V) Engineering psychology and human performance. Columbus, OH: Charles E. Merrill. Wickens outlines his model of human information processing upon which the current paper based its conceptualization with respect to the impact of the space environment on human performance.

Wood, F. R., & Dunivin, K. O. (1985). The human sub-system in extended, isolated, and confined environments. In Psychological, sociological, and habitability issues of long-duration space missions. NASA TR T-1082K. Houston: National Aeronautics and Space Administration. This unique report analyses the possible impact of the orbital environment upon social psychological outcomes including role specifications and group cohesion.

Walter Reed Army Institute of Research. Human performance in continuous/sustained operations and the demands of extended work/rest schedules: An annotated bibliography. Washington, D. C.: Walter Reed Army Institute of Research, Division of Neuropsychiatry. Any researcher involved in the effects of long-duration space missions on human performance should obtain a copy of this report. It provides an annotated bibliography of 399 research papers in the field of sustained operations.

ANNOTATED BIBLIOGRAPHY: PERSONALITY

- Alkov, R. A. and Borowsky, M. S. (1980) A questionnaire study of psychological background factors in U.S. Navy aircraft accidents. Aviation, Space and Environmental Medicine, 51 (9), pp. 860-863.

Summarizes previous research on personality characteristics of Navy jet pilots. Gathered data using questionnaires sent to flight surgeons investigating accidents. Found that pilots causally involved in accidents were more likely to be: (1) considering separation from the service; (2) having trouble with interpersonal relationships; (3) emotionally immature; (4) low in humor and humility concerning themselves; or (5) suffering a recent loss or bereavement.

- Ashman, A. and Tefler, R. (1983). Personality profiles of pilots. Aviation, Space, and Environmental Medicine, 54 (10), pp. 940-943,.

Samples of fighter pilots and commercial pilots were compared to nonflying males. Consistent with two earlier studies using the Edwards Personality Preference Schedule, both categories of pilots were found to have high achievement needs, to be dominant, to seek change, and to be both aggressive and heterosexual.

- Christensen, J. M., and Talbot, J. M. (1986). A review of the psychological aspects of space flight. Aviation, Space, and Environmental Medicine, 57, pp. 203-212,.

Discusses both documented and anecdotal in-flight perceptual, cognitive, and emotional impairments experienced by astronauts to date. Identifies four major categories of factors that influence spacecrew behavior. Suggests future areas of research to reduce uncertainty on optimal selection, training, and reinforcement for future spacecrews.

- Connors, M. M., Harrison, A. A., and Akins, F. R. (1986). Psychology and the resurgent space program. American Psychologist, 41 (8), pp. 906-913.

Presents psychological issues believed to impact future space missions. Emphasizes the importance of biobehavioral responses, human factors, communications, and personal and social adjustment in space. Suggests that the psychological community has much to offer the space program beyond selecting qualified astronaut candidates.

- Cooper, C. L. The stress of work: An overview. (1985). Aviation, Space, and Environmental Medicine, 56, pp. 627-632.

Concise but thorough look at potential occupational stressors and how they relate to job dissatisfaction and ill health. Factors intrinsic to the job and the homelife-work interface are discussed. Occupational stress for aviators is mentioned only briefly.

Deci, E. L., and Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behavior. New York: Plenum Press.

Suggests that intrinsic motivation is based on the organism's need to be competent and self-determining. Summarizes the most important work in this area, e.g., cognitive evaluation theory, and devotes the last four chapters to application in specific areas, such as education or work.

Epstein, S. (1977). Traits are alive and well. In D. Magnusson and N. S. Endler (Eds.), Personality at the crossroads: Current issues in interactional Psychology. Hillsdale, New Jersey: Lawrence Erlbaum.

A brief chapter that defends the concept of the personality trait and its usefulness in prediction if correctly used by researchers. The impact of situations on behavior is also discussed.

Eysenck, H. J. (1982). Personality, genetics, and behavior: Selected papers. New York: Praeger.

Discusses several aspects of his approach to personality. Of particular interest is his thorough discussion of introversion versus extroversion in the first two sections of the second chapter. (His detour onto genetical analyses of personality, however, is not relevant to this chapter.)

Fischman, J. (1987). Type A on Trial. Psychology Today, pp. 42-50, February.

Reviews recent research on the type A behavior pattern (TABP). Suggests that earlier studies did not adequately identify the strong self-involvement and cynicism underlying TABP. Discusses self-modification programs to reduce the anger and irritability expressed with TABP.

Goldberger, L. (1982). Sensory deprivation and overload. In L. Goldberger and S. Breznitz (Eds.), Handbook of stress. New York: Free Press.

Brief review of research findings and theoretical formulations regarding sensory deprivation and also sensory overload. (Excellent references.)

Green, R. G. (1985). Stress and accidents. Aviation, Space, and Environmental Medicine, 56, pp. 638-641.

Discusses different factors that may cause an aviator to become stressed. The evidence relating stress to aircraft accidents is also reviewed. Suggests that domestic or life stress may be a major factor in aviation accidents.

Haakonson, N. H. (1980). Investigation of life change as a contributing factor in aircraft accidents: A prospectus. Aviation, Space, and Environmental Medicine, 51 (9), pp. 981-988.

Study examines specific aircraft accidents and whether life change could be a significant contributing factor. (Major difficulty is the retroactive nature of the "life change" decision.) Recommends that aircraft management monitor such situations given the accident potential.

Helmreich, R. L., Wilhelm, J. A., and Runge, T. E. (1980). Psychological considerations in future space missions. In S. T. Cheston and D. L. Winter (Eds.), The Human Factors in Outer Space Production (Selected Symposium No. 50, pp. 1-23). Washington, D. C.: American Association for the Advancement of Science.

Suggests that future crews may have negative reactions to space if preventive measures are not taken. Looks at the changing goals of future missions, new crew composition, and changing costs and rewards for participants. Factors in crew selection and composition, authority structure, mission length and the optimal physical environment were discussed. More research is recommended.

Janis, I. L. (1982). Decisionmaking under stress. In L. Goldberger and S. Breznitz (Eds.), Handbook of Stress. New York: Free Press.

Looks in detail at the detrimental effects of stress on human decision-making. Proposes a conflict-theory approach to understanding stress effects. Contains a good discussion on hypervigilance and near-miss experiences. Concludes by covering ways to prevent defective decision-making under typically stressful conditions.

Jones, D. R., and Annes, C. A. (1982). The evolution and present status of mental health standards for selection of USAF candidates for space missions. Aviation, Space, and Environmental Medicine, 53, pp. 730-734.

Details the early selection process for astronaut candidates and compares those criteria to current selection processes. The inclusion of astronauts with a non-flying background introduces new factors, which are discussed. Recommends that selection standards be continually reviewed and refined to maximize both efficiency and relevancy.

Kanas, N. (1985). Psychological factors affecting simulated and actual space missions. Aviation, Space, and Environmental Medicine, 56, 806-811.

Reviews the findings of over 60 American and Russian experiences of people exposed to conditions of monotony, isolation, and confinement. Included are simulations, spaceflight studies, wintering over in the Antarctic, and so on. The author concludes that individuals in confinement are subject to serious psychological and social stresses, which have the potential to impair performance.

Kobasa, S. C., and Puccetti, M. C. (1983). Personality and social resources in stress resistance. Journal of Personality and Social Psychology, 45 (4), pp. 839-850.

Examines personality, social assets, and perceived social support as stress moderators. Stress was reduced by a "hardy" personality and perceived supervisor support, but was increased by negatively perceived life events. Suggests the importance of differentiating between different types of social support, e.g., family support versus supervisor support.

Kruglanski, A. W. (1986). Freeze-think and the Challenger. Psychology Today, pp. 48-49, August.

Approaches the tragedy of the Challenger explosion as a failure of human decision-making strategies. Analyzes where the decision to launch was "frozen" and makes recommendations on how to improve the decision making process.

Magnusson, D., and Endler, N.S. (1977). Interactional psychology; present status and future prospects. In D. Magnusson and N. S. Endler (Eds.), Personality at the crossroads: Current issues in interactional psychology. Hillsdale, New Jersey: Lawrence Erlbaum.

Theory-relevant discussion of the probable components of an interactionistic approach to understanding human behavior. Makes conceptual distinctions regarding methods, kinds of data, mediating variables, reaction variables, and relative versus absolute behavioral consistency. (Uses a limited number of practical examples.)

Magnusson, D. (1982). Situational determinants of stress: An interactional perspective. In L. Goldberger and S. Breznitz (Eds.), Handbook of stress. New York: Free Press.

Demonstrates how an actual interactionist analysis can be conducted. (Several studies cited deal with very young subjects; not applicable to this chapter.) The person - situation interaction models used in the attachment to this chapter were based on his empirical techniques.

Mischel, W. (1977). The interaction of person and situation. In D. Magnusson and N. S. Endler (Eds.), Personality at the crossroads: Current issues in interactional psychology. Hillsdale, New Jersey: Lawrence Erlbaum.

(Mischel's 1968 critique on personality psychology was well-received and forced the personality field to defend and re-think some of its assumptions.) This chapter re-defends the author's older criticism of the consistency and predictive ability of personality theory, and then defends and explains some aspects of the person - situation interaction approach to understanding human behavior.

Morris, L. W. (1979). Extroversion and introversion: An interactional perspective. New York: Hemisphere Publishing.

The personality concept of extroversion/introversion is examined in detail. The author re-examines existing research from a person-environment interactionist viewpoint. The relationship between extroversion/introversion and other personality variables, such as sensation-seeking and locus of control, is also explored.

Olweus, Daniel. (1977). A critical analysis of the "modern" interactionist position. In David Magnusson and Norman S. Endler (Eds.), Personality at the crossroads: Current issues in interactional psychology. Hillsdale, New Jersey: Lawrence Erlbaum.

Defines interactionism and the hypothetical methodology required to put this concept to work. Suggests future research paradigms and their analysis. (A brief chapter, but useful as background material.)

Santy, P. (1983). The journey out and in: Psychiatry and space exploration. The American Journal of Psychiatry, 140, pp. 519-527.

Comprehensive look at previous psychological findings and implications relevant to spaceflight. Includes review of previous astronaut selection procedures, a summary of findings from other isolated or confined environments, and a discussion of the stress-relevant training goals employed by the Soviets in their space program.

Schmidt, D. E., and Keating, J. P. (1979). Human crowding and personal control. Psychological Bulletin, 86 (4), pp. 680-700.

An extensive review of research findings regarding human crowding. Of interest are the findings that a warning initially increases negative perceptions, but then facilitates effective responding, that crowding is more aversive in primary environments, and that subjects will feel less crowded if distracted.

Ursano, R. J. (1980). Stress and adaptation: The interaction of the pilot personality and disease. Aviation Space Environmental Medicine, 51 (11), pp. 1245-1249.

The normal pilot personality is discussed. The author contends that some personality characteristics and coping styles that are adaptive in the flying environment are maladaptive in other settings. Case studies are used as illustrations.

Zuckerman, M. (1979). Sensation-seeking: Beyond the optimal level of arousal. Hillsdale, N. J.: Erlbaum.

The author defines the personality trait of being high in sensation-seeking as measured by his Sensation Seeking Scale. He proposes that it is strongly influenced by the physiology of an optimal level of arousal and discusses the validation of his theory.

Zuckerman, M. (1983). A biological theory of sensation-seeking. In M. Zuckerman (Ed.), Biological bases of sensation-seeking, impulsivity, and anxiety. Hillsdale, New Jersey: Lawrence Erlbaum.

More implications of the sensation-seeking personality trait are discussed. Since he also served as the editor of this book, Zuckerman comments on each chapter. Several of his statements relating anxiety and impulsivity to sensation-seeking are of some interest.

ANNOTATED BIBLIOGRAPHY: SLEEP PERFORMANCE

Akerstedt, T. & Gillberg, M. (1982). Displacement of the sleep period and sleep deprivation. Human Neurobiology, 1, 163-171.

Reviews the literature on the sleep/wake disturbances in shift work and connects them with recent research on circadian rhythmicity and sleep deprivation. Essentially, the disturbed day-sleep of shift workers is seen as resulting from a combination of circadian rhythmicity and sleep loss.

Baekeland, F. & Hartmann, E. (1970). The need for sleep. In Hartmann, E. (Ed.), Sleep and Dreaming. Boston: Little, Brown, & Company.

This chapter discusses the need for sleep in terms of average people's needs and the need of those that routinely require more or less. The phases of sleep as defined by brain wave activity and measured by EEGs are identified. The role of dreams and the need for dreams is addressed. Personality variables related to various sleep patterns are outlined.

Cairns, J., Knowles, J.B., & MacLean, A. W. (1982). Effect of varying the time of sleep on sleep, vigilance, and self-rated activation. Psychophysiology, 19 (6), 623-628.

This study examines the effect of varying the time of sleep on the time of the sleep, vigilance, and self-rated activation of 9 subjects. Presents evidence contradictory to most other studies, concluding that shifts in the conventional sleep period did not impair performance.

Conners, M.M., Harrison, A.A., & Akins, F.R. (1986). Psychology and the resurgent space program. American Psychologist, 41 (8), 906-913.

Reviews some of the psychological aspects of contemporary and impending space missions and discusses how the knowledge and skills of the psychological community can contribute to the program's success.

Czeisler, C.A., Weitzman, E.D., Moore-Ede, M.C., Zimmerman, J.C., & Knauer, R.S. (1980). Human sleep: Its duration and organization depend on its circadian phase. Science, 210, 1264-1267.

Studied variations in sleep length in 12 subjects who were living on self-selected schedules in an environment free of time cues. It was found that the duration of sleep episodes was highly correlated with the circadian phase of body temperature at bedtime, not with the duration of prior

wakefulness. Several interesting aspects of REM sleep and dreaming episodes are also correlated with body temperature rhythm.

Foulkes, D. (1966). The psychology of sleep. New York: Charles Scribner's Sons.

Attempts to summarize and interpret the status of experimental research on psychological aspects of sleep. This approach results in an emphasis on REM sleep and dreaming as the primary psychological aspect of sleep.

Hales, D. (1981). The complete book of sleep: How your nights affect your days. Reading, Massachusetts: Addison-Wesley Publishing Company.

Takes a prescriptive look at diagnosing sleep problems. Provides a good review of numerous aspects of sleep and then uses a physician's desktop reference format style to identify common problems and concerns, causes, and solutions.

Hartmann, E. (Ed.) (1970). Sleep and dreaming. Boston: Little, Brown, & Company.

This book is a collection of articles by noted sleep researchers covering nearly all the topics of interest to current studies. The chapters are predicated on answering a number of overhead questions at the beginning of the chapters.

Kleitman, N. (1963). Sleep and Wakefulness. Chicago: University of Chicago Press.

Classic book on the subject of sleep. Well written and informative.

Oswald, I. (1972). Sleeping and waking. Amsterdam: Elsevier Publishing Company.

A more technically oriented text designed to update the work of Kleitman with the more current and comprehensive research that was available at the time.

Roth, T., Roehrs, T., & Zorick, F. (1982). Sleepiness: Its measurement and detriment. Sleep, 5, S128-S134.

Proposes an operational definition of sleep disruptions in terms of understanding their effect on waking functions. Proposes that researchers use of the MSLT as a standardized test that provides with a tool for better understanding normal variations in sleep and the nature of sleep disorders.

Smith, R.E., Sarason, I.G., & Sarason, B.R. (1986). Psychology: The frontiers of behavior. New York: Harper & Row Publishers.

This general psychology text provides a good overview of the area of sleep.

Webb, W.B. (1975). Sleep: The gentle tyrant. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

This book tries to avoid the "textbookish" nature of other volumes on the subject and to appeal to people with minimal technical expertise. Uses illustrations from Dr. Seuss books to emphasize his points.

Wever, R.A. (1984). Properties of human sleep-wake cycles: Parameters of internally synchronized free-running rhythms. Sleep, 7 (1), 27-51.

Well written article that addresses many studies which used human subjects. Discusses differences attributable to the sex of the subject and identifies the characteristic differences that are commonly noted between males and females.

ANNOTATED BIBLIOGRAPHY: STRESS

Albrecht, K. (1979). Stress and the manager. Englewood Cliffs: Prentice-Hall, Inc.

Albrecht analyzes occupational stress. He discusses how people stress themselves, stress' impact on the quality of life, its evolution as a management problem, and various stress reduction techniques.

Brown, B. B. (1977). Stress and the art of biofeedback. New York: Harper and Row.

This work was the first comprehensive formulation on how to use biofeedback to treat a variety of conditions related to stress.

Goldberg, L; Breznitz, S. (1982). Handbook of Stress: Theoretical and clinical aspects. London: The Free Press.

Perhaps the most complete work on the overall concept of stress. Discussed are the basic psychological processes, biological process, research paradigms, common stressors, somatic conditions, extreme cases of stress and various treatments and support systems.

Krohne, H. W., and Laax, L. (1982). Achievement, Stress, and Anxiety. New York: McGraw Hill.

This work describes advances in achievement-related stress and anxiety research. Discussed are articles on theoretical and methodological issues, strategies of coping with stress, anxiety as the centered emotion elicited in achievement situations, achievement motivation and attribution theory.

Kutash, L. L. and Schlesinger, L. B. (1980). Handbook on Stress and Anxiety. San Francisco: Jossey-Boss Publisher.

This work presents a comprehensive overview on the progress that has been made in the theoretical understanding of stress and anxiety. Articles are presented in the areas of learning and behavioral theories, developmental theories, sociological theories, and physiological theories on stress and anxiety. Selye's general adaptation theory is explained; Lazarus' work on cognitive styles and coping is reviewed; and life events perspective is presented. Finally, a clinical orientation toward treatment is presented in six chapters.

Maddi, S. R. and Kobasa, S. C. (1984). The hardy executive. Homewood, Illinois: Don Jones-Irwin.

The authors describe the most important stress-resistant resource as a personality style referred to as hardiness. Hardy people feel in control, are involved in what they are doing, and are challenged by new experiences. They also discuss stress management strategies using their hypotheses.

Pines, A. M. and Aronson, E. (1981). Burnout: From tedium to personal growth. New York: The Free Press.

The authors describe the condition of burnout as states of physical, emotional, and mental exhaustion. They suggest that burnout has detrimental psychological effects that appear to be major factors in low morale and other job related factors. The authors describe the symptoms, danger signs, causes and strategies for coping with burnout.

Wetzel, J. M. (1984). Clinical handbook of depression. New York: Garden Press.

This book is a comprehensive, interdisciplinary approach to major psychological models on the incidence, causes, and interventions for depression. Wetzel covers diagnosis, psychoanalytic theories, life-events models, a person-environment model, behavior theories and biochemical theories.

Woolfolk, R. L. and Lehrer, P. M. (1984). Principles and practice of stress management. New York: The Guilford Press.

A complete work on the current treatment methods that use relaxation as the basic premise. Included are chapters on progressive relaxation, yoga, meditation, hypnosis, biofeedback, autogenic training, pharmacological methods, cognitive approaches, and current research methods.